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Contents.

	PAGE
Forthcoming Events	77
An Educational Metamorphosis	77
Expert Knowledge	77
Modern Metallurgical Research	78
The Institute of Metals	78
Random Shots	78
Mass and Skin Effects in Cast Iron	79
Alloys Now Cast in Great Britain	81
I.B.F. Elects New Members	82
High-Duty Cast Irons	83
Iron and Steel Manufacturers and Proposed Tariff Truce	87
London Iron and Steel Exchange	87
The Cooling and Solidification of Metals	88
Metal Firm's Jubilee	89
Elasticity and Fatigue Strength of Cast Iron	90
Progress in Metallurgical Research	92
Trade Talk	94
Contracts Open	94
Personal	94
Obituary	94
Iron and Steel Markets	96

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

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Forthcoming Events.

JANUARY 31.

Electroplaters' and Depositors' Technical Society :—Convention and exhibition at the Northampton Institute, London. Address on "Research and Practice," by Dr. W. Rosenhain, F.R.S., also a discussion on "Present Position of Chromium Plating."

FEBRUARY 1.

Staffordshire Iron and Steel Institute :—Sixty-fourth annual dinner at the Dudley Arms Hotel, Dudley.

FEBRUARY 3.

Society of Chemical Industry (London Section) :—Ordinary meeting. "Chemical Disarmament," Paper by Dr. Herbert Levinstein, M.Sc., F.I.C.

FEBRUARY 4.

Institution of Automobile Engineers :—Ordinary meeting in London. "The Relative Safety of Mild and High Tensile Steel under Alternating and Pulsating Stresses," Paper by Professor B. P. Haigh.

The Sir John Cass Technical Institute :—Ordinary meeting. "The Value of Metallurgical Research to Foundry Practice," Paper by H. C. Dews.

FEBRUARY 7.

Junior Institution of Engineers :—Ordinary meeting in London. "Co-operation between Technical Institutions and Industry," Paper by G. F. O'Riordan, B.Sc.

Society of Chemical Industry :—Ordinary meeting at Birmingham. "Electric Furnaces for Heat-Treatment," Paper by A. G. Lobley.

FEBRUARY 17 to 28.

British Industries Fair, at London and Birmingham.

Institute of British Foundrymen.

JANUARY 31.

London Branch (Junior Section) :—Ordinary meeting at 49, Wellington Street, London. "Some Notes on Patternmaking and Moulding," Paper by J. D. Hotchkis.

FEBRUARY 4.

Birmingham, Coventry and West Midlands Branch :—Annual dinner.

An Educational Metamorphosis.

No profession is allowed to be the sole arbiter of its own educational requirements. Medicine, law and the other older professions are controlled, inasmuch as aspirants must furnish, before entering upon their technical studies, a certificate of general educational proficiency equal to the London Matriculation Examination. This external control is now considered essential if the caché given is to have real recognition. In the earlier stages of training for many subjects it is desirable that they should be of a part-time character, and that a certain amount of latitude should be accorded, in certain practical subjects, so as to take cognisance of local conditions, whether they be tropical medicine or the light-castings industry. Because of these orientations, there must be some central co-ordinating body which can evaluate these in relation to the whole subject.

In industrial technical education the requirements are different from the older professions, as its make-up is divided into the executive officers and the operatives. There is a demand for the creation of nationally-recognised certificates in both sections in the foundry industry. Machinery exists for the immediate launching of both schemes, provided the demand from the industry is formulated on a rational basis by a representative national organisation. Happily, all these conditions exist within the foundry industry, and it can now be stated that active steps are being taken for the rapid consummation of this long-expressed ideal. Briefly, the scheme envisaged has taken cognisance of the academic and practical requirements of the industry by the provision of two types of certificates. It is designed to utilise to the maximum existing educational facilities in the various centres. It has created a well considered syllabus ready for incorporation into the curriculum of technical colleges, which have not yet taught foundry practice. Distinct provision is made for the orientation of the syllabus to take care of local exigencies. Finally, nothing has been done which might later prevent the Institute of British Foundrymen from later on arranging an entrance examination for admission to its ranks.

When the scheme which we have outlined, and which we believe represents the views of the Council of the Institute of British Foundrymen comes into force, it will be an event destined materially to influence the whole educational structure upon which the industry of cast metals now rests.

Expert Knowledge.

We have travelled a long way to-day from the time when gas-light was eschewed as a dangerous experiment and mechanical travel was considered a revolutionary and entirely ungentlemanly mode of progression. There are still, of course, a few persons among us who deplore the loss of some primitive human simplicity and the advance of knowledge—and scientific knowledge in particular—prophecying from it nothing but disaster, and forgetting that ignorance of a phenomenon does not improve its character. But the last few weeks have afforded several examples of the growing recognition of the value of exact knowledge, whether it be scientific or economic. Mr. Ben Tillett, M.P., speaking to the Trade Union Congress at Belfast not long since, said that "those industries which were successful in Britain to-day . . . were those which had organised themselves on scientific lines." At the beginning of December, Mr. A. J. Cook, speaking at Rugby, stated that economics must control politics. And in an entirely different sphere, and on an entirely different platform, General Smuts delivered a lecture in Cambridge in which he emphasised the decline of parliamentary power, and stated that "it ought to become recognised that the scientific political expert is a necessary institution in national government." In brief, the day of the amateur, in industry and in politics, is over. There was a day when human knowledge was so limited in range that the learned man, so called, was able to encompass the whole of it in a lifetime. There was a time when human knowledge was not so limited, but still sufficiently restricted that the learned man was able to encompass the whole of one branch of it—mathematics, perhaps, or physics, or philosophy. But to-day human knowledge is so vast that our learned men confine themselves to one section of one branch, making that their own and attempting no more. Within that section they are masters; outside it they are

pupils in the lowest class. Side by side with this specialisation of knowledge there is the problem that faces the ordinary man. It used to be possible for him to acquire a smattering of such branches of learning, sufficient to meet his needs and solve his problems. Later he found it desirable to acquire rather more than a smattering, whence the growth of technical education and the enhanced value of the technical man in industry. To-day no man can hope to carry within himself sufficient learning to meet all his needs. He must be able and willing to consult the expert at every turn, and he will be successful, in large measure, only in so far as he does so. The principle is recognised in that most personal of all branches of learning, medicine; we never argue the necessity of consulting not merely a doctor but a doctor who has specialised in our particular complaint—eyes, teeth, and so on. The time is coming, if it has not already arrived, when the same principle must be extended to the less personal aspects of life. There are Government departments, there are research associations, there are works laboratories and information bureaux; all these in their own way contribute expert knowledge to the political or industrial chief. The lesson we are learning to-day is the impossibility of running anything, be it the country or the works, without the required expert knowledge always available—economic in the one case, and scientific in the other.

Modern Metallurgical Research.

Professor D. Hanson, D.Sc., delivered his presidential address to members of the University of Birmingham Metallurgical Society, at the Edgbaston Buildings of the University, on Tuesday night, January 21. Mr. E. G. West (Chairman of the Society) presided. The laboratories were open for inspection, demonstrations being given by the staff and students.

In his address Professor Hanson dealt with the subject of research in the metallurgical department, emphasising its value as influencing teaching and being of service to industry. One of the problems industry had to face, he said, was the application of research results to manufacturing processes. That generally involved what might be called development work, whereby experiments carried out on a small scale were extended and applied on a large scale. The transfer often involved the solving of new problems, and its satisfactory accomplishment required resources, both in equipment and personnel, larger than the scientific research itself. The resources of the University of Birmingham enabled it to undertake work of that nature in its metallurgical technology laboratories. During recent years it had, in fact, contributed its share to the development of new alloys: for example, aluminium bronze, aluminium brass, ternary lead alloys for cable sheathing and pipes, and alloy cast irons. Development work on those materials had been carried out in the University, and had assisted in getting them brought into use.

SIR WALTER RAINE, President of the Associated Chambers of Commerce, speaking in Newcastle-upon-Tyne, said that the Five Counties Scheme had had an adverse effect on British shipping, and alleged that often, when steamers had been laid up and had been paying demurrage, those in control of the scheme had refused to increase the quota. The Durham and Northumberland schemes afforded a contrast. In Northumberland the only arrangement had been to maintain prices for certain coals, and in Durham it was even more simple, because it was only a tacit agreement as to what price there should be. Yet those arrangements had been stronger than those of the Five Counties Scheme.

The Institute of Metals.

ANNUAL GENERAL MEETING.

The 22nd annual general meeting of the Institute will be held, by kind permission, in the Hall of the Institution of Mechanical Engineers, Storey's Gate, London, S.W.1, on March 12 and 13, and the following Papers are expected to be submitted:—

"Experiments on the Influence of Gases on the Soundness of Copper Ingots," by N. P. Allen, M.Met.; "Unsoundness in Bronze Castings," by E. J. Daniels, M.Sc.; "Gases in Copper and their Removal," by W. E. Prytherch, M.Sc.; "Protective Value of Some Electro-Deposited Coatings," by L. Davies and L. Wright, B.Sc.; "The Diffusion of Zinc in Copper Crystals," by C. F. Elam, M.A., D.Sc.; "Macrostructure of Cast Alloys. Effect of Turbulence Due to Gases," by R. Genders, M.B.E., M.Met., F.I.C.; "The Aluminium-Brasses," by R. Genders, M.B.E., M.Met., F.I.C.; "Atmospheric Action in Relation to Fatigue in Lead," by Professor B. P. Haigh, D.Sc., and B. Jones; "Investigation of the Effects of Impurities in Copper. Part VI—The Effect of Phosphorus in Copper," by D. Hanson, D.Sc., S. L. Archbutt, F.I.C., and Grace W. Ford, B.Sc.; "A Note on Metallic Magnesium," by W. R. D. Jones, M.Sc.; "A Note on Zinc-Base Die-Casting Alloys," by R. Lancaster, B.Sc., and J. G. Berry, B.Sc.; "The Early Use of the Metals," by T. A. Rickard, D.Sc., A.R.S.M.; "The Composition of Eutectics," by D. Stockdale, M.A., Ph.D.

Annual Dinner and Dance.

The annual dinner of the Institute will be held on Wednesday, March 12, at 6.45 for 7 p.m., at the Hotel Victoria (Edward VII Rooms), Northumberland Avenue, London, S.W.1. The dinner will be followed by a dance, which will continue until 1 a.m.

Visit to British Industries Fair, Birmingham.

Thanks to the courtesy of the Fair Management Committee, members of the Institute are invited to visit the British Industries Fair, Birmingham, on Friday, February 21, and to partake of luncheon at the Fair. Reduced fare railway vouchers will be available, and members desiring to take part in the visit should notify the Secretary.

May Lecture.

The annual May lecture will be given on May 7, by Major F. A. Freeth, O.B.E., D.Sc., Ph.D., F.R.S. (Joint Research Manager, Imperial Chemical Industries, Limited). Further particulars will be supplied in due course.

Autumn Meeting.

The Council has gratefully accepted an invitation from the Mayor and Corporation of Southampton to hold the annual autumn meeting in Southampton on September 9-12. This will be the first occasion on which the Institute has met in Southampton, and it is hoped that there will be a large attendance of members and their ladies. Interesting visits and excursions are being arranged. Full details will be announced later.

It is interesting to note that at this meeting the following gentlemen will be declared to have been elected members of Council:—Mr. Wesley Lambert (president of the Institute of British Foundrymen), Mr. H. C. Lancaster, Mr. A. H. Mundey, A. J. G. Smout, Prof. F. C. Thompson, and Mr. F. Tomlinson.

Readers of THE FOUNDRY TRADE JOURNAL, who are not members of the Institute, can gain admission to the meetings by signing the visitors' book outside the meeting hall. The present time is certainly the most advantageous for joining the Institute.

All communications should be addressed to the Secretary, Mr. G. Shaw Scott, 36, Victoria Street, Westminster, London, S.W.1.

Random Shots.

Among my recent peregrinations, through the pioneering pages of the juvenile FOUNDRY TRADE JOURNAL, I encountered an article (dated 1902) entitled "The American Workman," and containing a fairly extensive account of a book on the subject by a Frenchman, M. E. Levasseur. At this I pricked up my ears—or should I say, my eyes?—for the most interesting and stimulating study of American conditions that I have read lately was Siegfried's "America Comes of Age," and Siegfried is also a Frenchman. If anyone can suggest to me a means of obtaining the earlier book, I should be more than grateful, for even the comparison of a whole volume with a couple of columns lent colour to my belief that the solution to some of our own problems lies in a study of the history of the last two or three decades of American industry. I know nothing whatever about this M. Levasseur, but I do know that it is inevitably more instructive to compare the impressions of fellow-countrymen than of foreigners—they react in the same way and they are struck by the same features.

* * *

In particular, this comparison, so far as I was able to make it, proved conclusively that the high standard of living in the United States is no mushroom growth. I read in "America Comes of Age" the following: "The daily life of the majority is conceived on a scale that is reserved for the privileged classes elsewhere," and "the United States owned 81 per cent. of all the automobiles in existence, or one for every 5.6 people, as compared with one for every 49 . . . in Great Britain"; and again, "in 1925-6 an unskilled labourer earned an average of 3 to 5 dollars a day." Reflecting that these were merely post-war abnormalities, I had a nasty bump when my 1902 authority informed me that "it is very common in the West, and not rare in the East . . . for workmen to keep their own carriages"; and "as a rule the American workman gives his wife about 25s. a week to keep house on, and perhaps 8s. or 12s. a week more for her own personal expenses." One is no longer surprised at anything, even at the provision of accommodation at the May Fair Hotel and an allowance of 33s. a day for the typists accompanying the American delegation to the Naval Conference!

* * *

Without Levasseur's original, I cannot say much as to the causes to which he ascribes this prosperity. I only know that he speaks of the American workman as temperate and religious, a strenuous and independent worker with initiative and a high productive capacity, and he also cites the advanced mechanisation of industry and the habit of keeping it absolutely up to date. With a whole volume of interesting data to draw upon, I dare not embark on an analysis of my more recent authority, though his speculations for the future are as interesting as his conclusions anent the past. Some of you, after all, may not be interested in American prosperity, although I maintain that you ought to be! So I'll quit moralising, and leave you to study the subject for yourselves!"

* * *

Did I tell you the story of the burglar who had pleaded "Not Guilty," and was asked by the Judge if he had anything to say before sentence was passed. "Well, my lord," he said, "there's only this, that to be h'identified by a bloke wot 'ad 'is 'ead under the bedclothes all the time ain't my idea o' British justice!"

MARKSMAN.

Mass and Skin Effects in Cast Iron.

By Dr. Swift, Bradford Technical College.

Until recently there seems to have been a variety of opinion and little certain knowledge as to the extent to which the mechanical properties of cast iron are affected by:—(*a*) The transverse section of the bar as cast, and (*b*) machining to various depths below the skin. These two effects, which may be termed the mass effect and the skin effect, are, of course, quite distinct from one another, but they are dependent on rather similar basic conditions and are sufficiently related to be studied together.

Apart from a systematic series of tests by the American Foundrymen's Association, which showed the modulus of rupture of bars 1 in. sq. to be nearly thrice that of those cast 3 in. sq., such experimental work as was published before about 1923 was of rather a desultory character. As regards the effect of machining, experience was divided. The impression was generally held that the strength of cast iron resides more especially in the skin; but Unwin and others, on the other hand, insisted that removal of the skin does not weaken a bar. During the last six years more serious attention has been devoted to these matters, and a good deal of information has been made available by Adamson and Bell, Russell, Shaw, and latterly by the British Cast Iron Research Association through its Director, Mr. J. G. Pearce. As a general rule in this work the transverse test has been assumed as the standard criterion of strength and relatively little regard seems to have been paid to tests of tensile or crushing strength, or hardness.

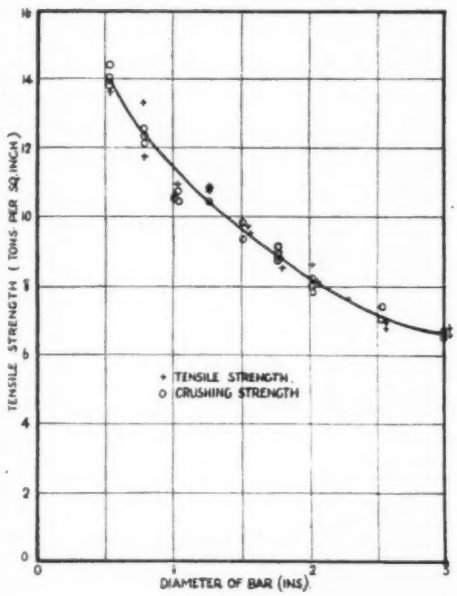


FIG. 1.

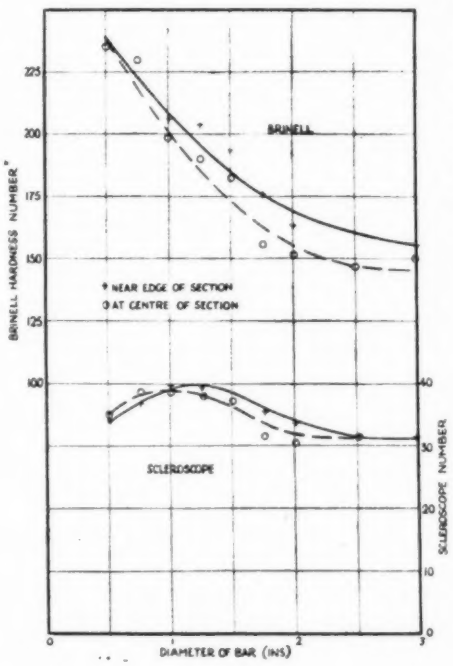


FIG. 2.

For practical foundry use the transverse test is unassailable on grounds of convenience, but as a means of scientific investigation it is not free from criticism. In the first place, it is not easy to interpret in terms of real intrinsic strength, for it depends not only on tensile and compressive strength, but also on such vestiges of ductility as the iron possesses, and to quite a considerable extent on the shape and proportions of the test-bar. Mr. Pearce, for example, himself admits variations in the ratio of rupture modulus to tensile strength from 1.59 to 2.18 in a single series of tests. Further than this, although a comparatively heavy bar is cast, it is virtually tested only across the section under the central load, and quite considerable flaws elsewhere may easily pass undetected. In the light of these considerations it is suggested that in any examination of mass and skin effects, satisfactory comparisons can only be made on the basis of the more fundamental forms of test.

B.E.S.A. Grey Iron Specification.

Authoritative British opinion at the present time on these effects is presumably reflected in the B.E.S.A. specifications for general grey-iron castings, although it must be admitted that engineers generally have hitherto shown little desire to adopt it. In this specification castings are classified according to the "main cross-sectional thickness," and the diameters of test-bars and stipulated values of the modulus of rupture and tensile strength are graded according to Table I:—

TABLE I.—*B.E.S.A. Specification for Grey Iron.*

Casting thickness.	Key.	Test-bar cast dia.	Modulus of rupture.		Tensile bar turned dia.	Ten. str.	
			Grade A.	Grade C.		Grade A.	Grade C.
< ¾ in.	S	0.875	24.2	19.6	0.564	12	10
¾ in.—2 in.	M	1.2	23.1	18.9	0.798	11	9
> 2 in.	L	2.2	19.2	17.2	1.785	10	9

Recognition of the mass effect is clearly indicated in these figures and also in the fact that allowances are made in the stipulated modulus of rupture for bars cast slightly over or under the specified dimensions; with the small bars a total variation in diameter of 23 per cent. corresponds to an allowance of 2.8 per cent., while with the large bars a variation of 9 per cent. receives an allowance of 4½ per cent. The consistency of this recognition of the mass effect is shaken, however, by the fact that transverse bars more than 0.1 in. over size are required to be turned down and tested at the correct size without allowance, and this requirement, coupled with the stipulation that all tensile bars shall be turned down, in some cases to less than half their original sectional area, leaves an impression that the skin-effect is regarded as unimportant.

Reference to less authoritative specifications and to technical literature generally will show that the strength of cast iron is commonly stated without any reference to the dimensions of the bar or casting, and frequently without mention of machining. Omissions of this kind, unless based on certain knowledge that the effects are negligible, are clearly ill-advised, for, apart from the fact that a test-bar which is not representative in dimensions would give an erroneous impression of the actual strength of a casting, it does not follow that the iron which gives the best test-bar will be best for each of a variety of sizes in castings. Again, if the skin is of special importance in determining the strength of cast iron, it is hardly reasonable to remove this skin before making tests.

This general review of the present position suggests that there is room for systematic inquiry into the effects of "mass" and "skin" on the mechanical properties of cast iron, and it is thought that a certain amount of useful material for this purpose is provided by a series of tests on bars of an ordinary grade of grey cast iron, cast in various diameters from ½ in. to 3 in., which was carried out recently at the Bradford Technical College by the present writer, with the assistance of Messrs. W. Snowden and A. S. Beedham. In order to make the tests truly comparable and as representative as possible, the bars were all cast vertically in dry-sand moulds from a single ladle of metal. The metal was poured at a temperature between 1,250 and 1,275 deg. C. and had the following approximate analysis:—T.C., 3.30; Si, 2.30; Mn, 0.45; S, 0.085 and P, 0.90 per cent.

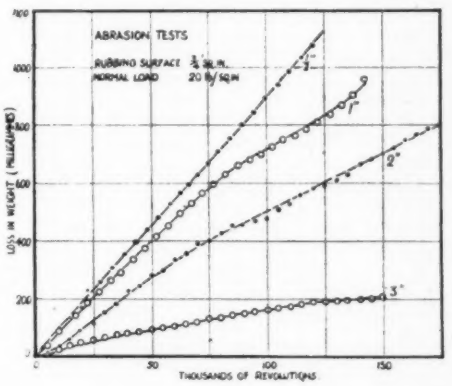


FIG. 3.

Nine bars were cast to each of the leading sizes and six to each of the others. The bars were all cast as for tensile test-pieces, with 6-in. parallel length and enlarged gradually at the ends to diameters corresponding to the various dies available. Compression specimens were cut from these bars as required.

Determinations of the free-carbon content of the various bars were made by the author's colleague, Mr. C. R. Groves, and these showed no measureable systematic difference over the whole range of bars. In view of the importance of this matter and the unexpected result, Mr. W. H. Poole, of Keighley Laboratories, kindly undertook an independent examination, in which

very special care was taken. A summary of representative results from this exhaustive series of tests is given in Table II, and it will be seen that they agree well among themselves and confirm Mr. Groves' conclusions. Having pretensions neither as chemist nor magician, the author is at a loss to reconcile these results with the indisputable fact that the bars were actually cast from the same ladle of molten metal. But for present purposes it is sufficient that differences in graphite content are negligible.

Table II.

Dia. of bar ..	2½		1½		½
Edge or centre ..	E	C	E	C	
Total carbon ..	3.17	3.16	3.35	3.33	3.42
Free carbon ..	2.41	2.43	2.40	2.41	2.41
Combined carbon (diff.)	0.76	0.73	0.95	0.92	1.01
Combined carbon (colour)	0.72	0.72	0.93	0.90	0.97

Methods of Testing.

The bars were tested for tensile strength, crushing strength, Brinell and scleroscope hardness, and in some cases for resistance to abrasion. Certain of the crushing tests required a machine heavier than the 100-ton testing machine installed at the Bradford College, and, with the permission of Prof. Dempster Smith, these tests were made at the Manchester College of Technology by Dr. H. Carrington, for whose kind co-operation the author tenders his sincere thanks.

The methods of testing call for little comment. In the tensile tests precautions were taken to ensure a truly axial load. For tests up to 25 tons grips of the Robertson type were employed, and beyond the capacity of these grips pairs of spherical-seated washers, specially made for the purpose, were inserted between the cross-heads and the main dies of the testing machine. The test-bars had screwed ends and were accurately centred before screwing. The parallel length of the bars was originally 6 in. in each case, but in some of the later tests, for which the bars were turned down, parts of previously fractured bars were employed and the test length was therefore less. With a material like cast iron there appears to be no objection to this procedure.

The compression tests were made between case-hardened steel surfaces and on a length of specimen equal in each case to 1.5 times its diameter. In the absence of any accepted specification this ratio was chosen as giving the shortest specimen which would permit failure to occur in the usual way at about 56 deg. to the normal section without end interference. This claim is supported by Hodgkinson's well-known test results.

The Brinell hardness-number was measured at the centre of the cross-section in each case, and also, in the larger bars, at a point about ¼ in. from the edge. Scleroscope determinations were made at various points across the section, but as it was found that intermediate readings lay consistently between the centre and edge readings, these alone are recorded. The abrasion tests were carried out on a newly-designed apparatus and consisted in measurement of the loss in weight of the test-pieces after definite amounts of pure sliding (about 8,000 ft. between successive weighings) under a constant normal pressure of 20 lb. per sq. in. Each specimen was rubbed against the same "standard"—a centrifugally cast-iron pipe, kindly given by Messrs. Newton, Chambers & Company, Limited—the surface of which was cleaned up dead smooth with a steel tool after each complete test. No intrinsic significance is claimed for the individual results; nothing more was intended than that they should be comparable with one another, but every reasonable precaution was taken to this end.

Discussion of Results.

The results of the tensile tests on the rough bars showed that, when reasonable allowance was made for the intrinsic uncertainties of cast-iron testing, the tensile strength varied in a clearly systematic way from a value of 14 tons per sq. in. for the ½-in. bar to about 6½ tons per sq. in. for the 3-in. bar. The relation between the diameter and the tensile strength is shown in Fig. 1, which is self-explanatory. The curve in this figure, although smooth and continuous, does not conform to any simple rational equation; an elaborate empirical approximation could be deduced, but this would have no general physical significance, and it is thought wiser to leave the results in graphical form.

The compressive tests on specimens taken from the rough bars gave, generally speaking, more consistent results than the tensile tests and showed a similar diminution in crushing strength, from about 70 tons per sq. in. for the ½-in. bar to 36 tons per sq. in. for the 3-in. bar. In Fig. 1 the results are plotted, as will be seen, to a scale of exactly five times that of the tensile tests, and the changes are so remarkably similar in the two cases that both tensile and crushing tests lie equally well along a single curve. In other words, for each of the bars under test the crushing strength is almost exactly five times the tensile strength. At first sight it is tempting to draw far-reaching conclusions from such a striking coincidence and to presume some physical connection between the causes of failure in tension and compression, but a reference to earlier published results shows that the compressive strength of cast iron does not commonly bear such a high ratio to its tensile strength, and a reference to results discussed later in the present Paper will show that this relationship ceases to hold when the bars are turned down to smaller diameters. Hence the similarity, although remarkable, is regarded to some extent as fortuitous.

Hardness Tests.

The results of the hardness tests have certain features of interest. As will be seen from Fig. 2, the Brinell number at the centre of the cross section of the bars varies in a reasonably systematic way from 235 for the ½-in. bar to 150 for the 3-in. bar, the change between the 2-in. and 3-in. bars being very small. The same figure shows that the Brinell number about ¼ in. from the skin is slightly but consistently greater than at the centre. These results conform generally to expectations. The scleroscope results, plotted for convenience on the same diagram, do not follow at all closely the Brinell numbers, particularly with the smaller diameters of bars. There seems to be an optimum value for a bar of 1 in. to 1½ in. dia., with again very little difference between bars of 2 in. and over. The scleroscope number at the centre of the section was found in the case of small bars to be greater than at a short distance (about 1/10 in. in this case) from the skin, although this condition was reversed between the 1-in. and 2-in. bars. With the two largest bars (2½ and 3 in. dia.) there was no appreciable difference in scleroscope readings between the centre and the skin. It is possible that the low values obtained with the smaller diameters are due to the less rigid clamping of the smaller specimens in the machine. This suggestion of course implies no criticism of the actual tests concerned, for if this effect is present it is an inherent feature of the instrument, and acceptance of the instrument involves acceptance of the results.

Abrasion Tests.

The results of the abrasion tests were specially interesting. In these tests three specimens each were taken from bars of ½, 1, 2 and 3 in. cast diameters, these sizes being chosen as representative of the whole range. In Fig. 3 are plotted the losses of weight sustained by these various specimens after successive periods of rubbing under identical conditions of load. It will be seen that although the rate of wear for the various specimens does not attain a very constant value yet the difference between the bars is marked and systematic. Curiously enough, those bars which were taken from bars of smaller diameters were worn away at a distinctly more rapid rate than those from the softer bars of larger diameter.

The conditions which control sliding abrasion are not sufficiently well understood to justify a confident explanation of these results. Apart altogether from the question of hardness, changes in the conditions of the rubbing surfaces during the process of abrasion are clearly of importance. Small particles of abraded material may affect the interface in two ways; they may modify the frictional conditions, or they may mask the intrinsic abrasive properties of the intact metal. Given constant abrasive qualities, it is reasonable to expect that the wear will be more directly dependent on the frictional resistance of the rubbing surfaces than upon the normal load between them. In the case of cast iron working under dry conditions the abraded material consists partly of iron oxide—oxidation being promoted, no doubt, by warmth and fine division—and partly of graphite. The graphite in particular will tend to form a partially-lubricating film on the rubbing surfaces and so to reduce the friction and the wear. In the bars of greater cast diameter it was found that the graphite was not present in any greater quantity, but it was present in larger and more lamellar particles. Whether this or the softer nature of the material exercised some influence, direct measurements showed that the friction was somewhat greater with the bars of small diameter. But in any case the differences between the measured co-efficients of friction were quite small, and wholly inadequate in themselves to account for the big differences in wear.

The effect of worn material on the abrasive properties of the surfaces may therefore be of some significance. The standard rubbing surface employed in all cases was a close-grained spun cast iron whose nature would be more closely allied to the smaller than to the larger test-bars. Hence this surface would seem less likely to become altered in nature by the specimens from the smaller bars, and the conditions of true continual abrasion would then be more nearly attained. In contact with the softer specimens from the larger bars, on the other hand, this surface would no doubt become to some extent clogged with the soft metal, so that its efficiency as an abrading medium would become impaired. The clogging of a fine file when used on a soft material like copper is an example of a similar effect. Alternatively it is possible that in the case of the softer bars the particles from the harder metal of the standard may become embedded in the surface of the softer specimen and so form an abrasive agent, protecting the softer matrix in which it is embedded and attacking the standard. It is known that, for a similar reason, mild steel is able to withstand certain types of abrasion better than much harder alloy steels, and diamond-dust embedded in the edge of copper discs is used for cutting rock sections.

Whether or not either of these factors is important, it is clear that the tendency made evident by the tests is too systematic to be accidental, and some important influence is needed to explain the unexpected nature of the results. The tests reproduce substantially the conditions of wear which would occur in practice in the absence of lubrication, and would therefore seem to have some real significance. They at least provide clear evidence that the value of impression-hardness as a criterion of resistance to wear is largely illusory in the case of cast iron. Further, having regard to the importance of wear as an ultimate cause of failure or replacement in service, the results suggest the need for a more systematic inquiry than has hitherto been attempted into the basic conditions underlying abrasion.

(To be continued.)

Alloys Now Cast in Great Britain.

By Thomas Henry Turner, M.Sc.

(*Continued from page 44.*)

Light Alloys.

The phenomenal development of road and air transport has caused an extraordinary expansion in the use of light-alloy castings in Great Britain, as, indeed, in all industrial countries. *Copper or zinc-aluminium alloys* are used for the bulk of the work. A copper, nickel and magnesium-aluminium alloy is the standard high-duty alloy, and the still lighter silicon-aluminium alloys are very popular where resistance to corrosion by sea-water is especially important.

TABLE XXIII.—*Chemical Compositions of British Standard Light Alloy Castings.* (*Air Board Specifications*, 1921, *and B.E.S.A. Specifications*, 1929).

Composition, aluminium plus		L.24 or "Y."	3.L.11.	No. 361.	2.L.8.	No. 362.	2.L.5.	No. 363.
Cu	Max.	4.5	8	8	13	13	3.0	3.0
	Min.	3.5	6	6	11	11	2.5	2.5
Zn	Max.	0.10	0.10	0.10	—	0.1	14.5	14.5
	Min.	—	—	—	—	—	12.5	12.5
Ni	Max.	2.3	—	—	—	—	—	—
	Min.	1.8	—	—	—	—	—	—
Mg	Max.	1.7	—	—	—	—	—	—
	Min.	1.2	—	—	—	—	—	—
Si	Max.	0.7	0.7	1.00	—	1.00	0.7	1.00
Fe	Max.	0.8	0.8	1.00	—	1.00	0.8	1.00
Pb	Max.	0.10	0.1	—	—	—	0.10	—
Sn	Max.	0.10	1.0	—	—	—	—	—
Total other metallic impurities		—	—	0.10	—	0.10	—	0.10

Magnesium-rich alloys have recently been introduced, and promise to find extensive use.

The results of very extensive researches into the properties of aluminium alloys were made generally available to industry when the British Air Board Specifications were published by the B.E.S.A. in 1921. These casting alloys have, since that date, been standardised almost throughout the whole industry, and the best of them (known generally as "Y" alloy, from its original designation during investigations at the National Physical Laboratory, which determined its unique properties) has recently gained greatly in popularity. A new British foundry, which specialises in the production of "Y" alloy castings, has been so successful that its manager was recently able to say in public that the cost of the erection of his foundry buildings had been written off in fifteen months, although he had never made a sales trip to solicit orders. "Y" alloy may therefore be said to be coming into its own, now that certain patent limitations which restricted its heat treatment have lapsed. A few years ago it was actually more widely cast in America than in the country of its invention. "Y" *alloy*, or L.24, as it is now called, is used for castings which have to withstand stresses at elevated temperatures, such as internal combustion engine pistons, but it is also used for many other highly-stressed parts and possesses an excellent resistance to corrosion. It is usually heat-treated at 510 deg. C. for 6 to 12 hrs., and then "aged" rapidly by boiling in water for an hour or two. It was used extensively in the construction of the British monoplane which last year flew non-stop from England to India in 50 hrs., and it forms essential components in many famous aero engines.

Practically without exception all the aluminium-rich alloys are cast to the well-known Air Board specifications, their analyses and physical and mechanical properties conforming essentially to these specifications. For general castings for automobile work, such as sumps, gearboxes, etc., the Air Board 2.L.5 and 3.L.11 are usually specified. These are the cheaper aluminium alloys, and since they are very similar in mechanical properties, the choice often depends upon foundry considerations in their casting and other properties. Pistons, and other components which are subjected to heat, are specified in Air Board 2.L.8 and L.24, the former being cheaper and the latter superior in properties. The newer modified silicon-aluminium and the magnesium-rich alloys are not cast by many foundries, their use at the present time being mainly confined to special purposes; moreover, these alloys are covered by royalty duties.

TABLE XXIV.—*Mechanical and Physical Properties of British Standard Light Alloy Castings.*

Properties.	L.24 or "Y."	3.L.11.	No. 361.	2.L.8.	No. 362.	2.L.5.	No. 363.	
U.T.S. tons sq. in.	11	9	9	9	9	11	11	Specified minima.
E.% on 2 in.	Nil	3	3	nil	nil	3	3	
U.T.S. tons sq. in.	17–22	—	—	—	—	—	—	Heat treated.
E.% on 2 in.	3–6	—	—	—	—	—	—	
U.T.S. tons sq. in.	11–12.5	9–10		9–11		11–13		Average figures in practice.
E.% on 2 in.	1–2	3–5		1–1.5		3–6		
Brinell hardness	90	55		77		65		
S.G.	2.79	2.89		2.95		2.97		
Coef. of expansion /°C.	0.000022	0.0000246		0.0000264		0.0000255		
Contraction on casting	1.29%	1.19%		1.25%		1.27%		

All of these alloys are poured, as a rule, from temperatures between 650 and 750 deg. C.

The substitution of mild-steel sheet pressings for certain of the more simple castings in aluminium alloys has occurred in many cases, but the replacement of these alloys as a whole is not to be expected. Die-casting, and similar processes whereby economies in machining are produced, is the chief trend of progress in the production of aluminium-alloy castings. After visiting foundries on the Continent and in America, the writer is of opinion that the casting of large articles in gravity-fed permanent metal moulds has been developed more successfully in Great Britain than elsewhere. This process of permanent mould-casting is widely used for gearboxes, crankcases and other relatively large articles required in large quantities. On the other hand, the various processes of pressure-fed die-casting have been largely introduced from abroad, and are mainly employed in casting quite small articles like brake shoes and weighing-machine and vacuum-cleaner parts.

The above Tables XXIII and XXIV refer to all the *light casting alloys* for which the B.E.S.A. has so far issued specifications, but doubtless many other alloys are cast in smaller quantities for special purposes. Many of these other alloys are cast under proprietary names, but differ little in other respects from those shown above. One alloy deserves especial reference here, however, as it has been used more widely than some others for aeroplane and motor-car cylinder heads, and generally for castings where high internal pressure is encountered. Its composition is: Copper, 8 per cent. max.; silicon, 2.5 per cent. max.; iron, 0.8 per cent. max., and aluminium, remainder, whilst its properties are: Y.P., 10 tons/sq. in.; U.T.S., 12 to 14 tons sq/in.; elongation, 2 to 3 per cent. on 2 in., and Brinell hardness, 85 to 90.

High-Silicon Aluminium Alloys.

High-silicon alloys of aluminium are frequently cast unmodified for pressure die-cast small parts of great accuracy. These alloys are rapidly increasing in popularity owing to their excellent foundry properties, superior resistance to corrosion, and good mechanical characteristics. They are actually lighter than pure aluminium in some cases, and possess a better elongation than any other cast light alloy of aluminium now in use. They are modified by the addition of a small quantity (0.1 per cent.) of metallic sodium or potassium, or by 3 to 4 per cent. of caustic potash or common soda. As mentioned above, these alloys are restricted in use to certain licensees and are sold under proprietary names, such as "Alpax," "Birmasil," "Silumin" and "Wilmil." They are being cast into many extremely complex and difficult shapes, such as the triple induction spiral of Bristol Jupiter aero engines, and the complete thin-section doors of London underground railway carriages.

Silicon-aluminium alloys have been used in the modified condition to a considerable extent for castings handling fresh water or oil, and appear to be the only light casting alloys to find favour with marine engineers.

An Admiralty specification for such material requires the following properties: U.T.S., 11 tons per sq. in. min. and 6 per cent. elongation on 2 in. min. Actual tests usually give: U.T.S., 13 to 14 tons per sq. in. and 10 to 14 per cent. elongation on 2 in.

Such alloys are poured at about 725 deg. C. and contract 1.33 per cent.; their co-efficient of expansion is 0.0000222 per deg. C.; their specific gravity 2.66. The foundryman is pleased that these alloys seldom crack in the mould, and are so ductile that offsize castings may frequently be set with a hammer. In building the structure of "R.101," the new passenger- and mail-carrying rigid airship erected at the Royal Airship works, many thousands of die castings in the 10 to 14 per cent. silicon-aluminium alloy have been used. The mechanical properties of

the chill-cast 1-in. test-pieces are: Minimum U.T.S., 12 tons per sq. in., and minimum elongation, 7 per cent. on 2 in., and the castings are sound, remarkably ductile and accurate to size.

Magnesium-Aluminium Alloys.

The production of alloys rich in magnesium on a commercial scale is relatively new in Great Britain, but it is an industry of very great promise. Details of two such alloys are given below, the first being used for motor-car crankcases, gear-boxes and aeroplane engine sumps, and other such parts where lightness is a primary essential is specific gravity being only 1.84.

Zinc-Aluminium-Magnesium Alloy.—Composition: Aluminium, 3.5 to 6.5 per cent.; zinc, 2.5 to 3 per cent.; manganese, 0.25 to 0.75 per cent., and magnesium, remainder. Properties: Y.P., 7.5 to 8.5 tons per sq. in.; U.T.S., 14 to 15 tons per sq. in.; elongation, 7 per cent. on 2 in., and Brinell hardness, 55.

Aluminium-Magnesium Alloy.—This alloy is used for general castings where hardness is required, its specific gravity being 1.86 to 1.89. Composition: Aluminium, 10 per cent.; manganese, 0.25 to 0.50 per cent., and magnesium, remainder. Properties: Y.P., 9.5 tons per sq. in.; U.T.S., 11 to 13 tons per sq. in.; elongation, 2 to 3 per cent. on 2 in., and Brinell hardness, 65.

The addition of manganese to these alloys and their surface treatment, by dipping into a solution of dilute nitric acid and potassium bichromate, has done much to overcome their liability to corrosion in service. The writer has seen these "Elektron" alloys cast in Great Britain with apparent ease in commercial foundry work, and he has seen both small and intricate die castings and large and massive sand castings which have been so produced. The melting point of these magnesium-rich alloys is in the neighbourhood of 635 deg. C., their pouring temperatures ranging from 680 deg. C. for thick to 780 deg. C. for thin castings.

Table XXV.—*Normal Range of Light Alloy Castings in a Modern British Foundry.*

Proprietary, or standard name.	U.T.S.	Brinell.	El.%	Sp. Gr.	Uses.
Birmalite	16–19	130–150	0–0.5	2.9	Pistons.
Birmidium "Y"	11–12·5	90	1–2	2.79	Pistons, brake shoes and all high-duty work.
" heat-treated	17–21	110	1.5–3	—	
Birmabright	9–10	53	5–8	2·66	Chemical engineering; shop fittings, ship fittings.
L.8 (12% Cu)	9–11	75–80	1–1·5	2·95	Ordinary pistons; close grain castings.
L.11 (7% Cu)	9–10	55	3–5	2.87	Die castings, where ductility is required.
L.5 (2.75% Cu, 13.5% Zn)	11–13	65	3–6	2.97	Sand-cast crankcases, etc.
Birmasil (13% Si)	12–14	56	7–12	2.68	Resistance to corrosion. Lighter than pure aluminium.

Table XXV may be found of interest, in that it shows the grades of *light alloy castings* normally produced by one of the best of the foundries which the author has visited in the Midlands, and may be regarded as typical of good practice in Great Britain.

Before concluding this reference to the light alloys, mention should be made of two processes of British invention which are now practised in the melting and casting of high-quality aluminium alloys. The heat-treatment of "Y" alloy, the modification of silicon alloys and the anodic oxidation for surface protection, have all contributed to the popularity of these alloys with the users. The foundryman is, however, probably more indebted to Mr. S. L. Archbutt for his process, known as "pre-solidification," by which it is possible to eliminate "speckled metal" and pinholes. A refinement of this process is to assist the elimination of the noxious hydrogen and other gases by passing a stream of nitrogen through the melt during its cooling process. In foundry practice this method results in better "Y" alloy and silicon-aluminium castings. In the case of the copper-aluminium alloys, Capt. George Mortimer, whose Papers have been of immense value to the whole industry, maintains that it is only necessary to treat the 50 to 50 hardener to a simple pre-solidification process to produce economically a marked improvement in the final casting.

The second process to which one should refer is that in which light alloys are modified by an entirely new method, which involves the use of chlorine and chlorine compounds, particularly boron trichloride. Having been patented, this process is perhaps of less general application, but it is being employed in the production of castings known as "Cindal" and in the refinement of secondary aluminium.

(To be continued.)

I.B.F. Elects New Members.

At a Council meeting of the Institute of British Foundrymen, held at the Imperial Hotel, Birmingham, on January 18, the following gentlemen were elected to its various grades of membership:—

As Subscribing Firm.

Dewrance & Company, 165, Great Dover Street, London, S.E.1, engineers' founders.

As Members.

H. Battye, coke and iron factor; A. Calderbank, engineer, Tilghman's Patent Sand Blast Company, Broadheath; T. F. Gilbert, secretary, Low Moor Iron Company, Aldwych, London, W.C.2; K. Gossell, managing director, Gossell & Son, London; C. S. Green, foundry manager, Haslam & Newton, Derbyshire; B. Hooper, C.B.E., managing director, The Foundry Trade Journal; W. H. Jones, works manager, Hamilton Woods & Company, Salford; F. H. Lister, works director, R. A. Lister & Company, Dursley; R. A. Lloyd, iron founder, Elm Street Lane Foundry, Cardiff; W. Milligan, foundry manager, Singer Manufacturing Company, Clydebank; J. Mitchell, iron-founder, Mitchell, Russell Company, Bonnybridge; H. A. MacColl, B.Sc., Assistant foundry manager, Partington Steel & Iron Company, Irlam; R. A. McLeod-May, manager, Renwick & Company, Kushtial, Bengal; J. F. Paige, deputy general manager, Wm. Mills, Limited, Birmingham; T. H. Preston, secretary, Chattan Foundry, Bonnybridge; W. Richards, engineer, Phœnix Iron Works, Leicester; A. Roebuck, local director, Hadfields, Limited, Sheffield; C. E. Williams, director, J. Williams & Sons, Cardiff; G. C. Williamson, director, D. Hart & Company, London, N.1; and J. H. Wright, designer and engraver, Amalgamated Press, London, S.E.1.

As Associate Members.

A. Burgess, moulder, Hollingdrake & Sons, Stockport; R. Carroll, metallurgical student, Mackinlay, Limited, Glasgow; A. J. Ceriez, iron moulder; W. G. Chapman, metallurgist, Renwick & Company, Kushtia; J. L. Dewfall, assistant foundry foreman, Guest, Keen & Nettlefolds, Cwmbran; R. P. Dodsworth, engineer and foundry manager; P. H. Durrans, apprentice moulder, T. Broadbent, Huddersfield; J. Erskine, moulder, G. & J. Weir, Limited, Cathcart; F. Fellows, moulder, Southern Foundries; G. E. Fisher, assistant foundry manager, H. Morris, Limited, Loughborough; G. Fraser, assistant foreman, G. & J. Weir, Limited, Cathcart; S. Gay, foundry foreman, Fine Castings, Limited, Fishponds; J. F. Greenway, research assistant, B.C.I.R.A., Birmingham; W. Hawley, foundry foreman, Blakebroughs, Limited, Brighouse; E. Henery, moulder, Linotype, Limited, Broadheath; C. H. Hillman, foundry foreman, S. Russell & Sons, Leicester; W. Holliday, works manager, Aluminium Bronze Company, Walsall; A. Holmes, foreman patternmaker, H. Morris, Limited, Loughborough; A. R. Howells, moulder, Globe Foundry, Cardiff; G. H. Jones, moulder, Ruston & Hornsby, Reddish; W. Jones, patternmaker, Goulds Founders, Limited, Cardiff; J. G. Keith, chemist, Carron Company, Carron; W. V. Linnett, foundry foreman, Cheetham & Hill, Limited, Derby; R. A. McDowall, patternmaker, Aeroplane Repair Section, Karachi, India; J. C. Morris, foundry foreman, Patent Axlebox & Foundry Company, Limited; J. E. Moss, moulder, Bellis-Morcom, Limited; W. Munro, patternmaker, G. & J. Weir, Limited, Cathcart; J. B. McHugh, foundry foreman, Mavor & Coulson, Glasgow; W. G. Russell, patternmaker, S. Russell & Sons, Leicester; E. Salt, foreman dresser, Davis Gas Stove Company, Luton; T. Smith, foreman steel moulder, Park Foundry Company, Derby; A. J. Stokes, moulder, J. H. Robinson & Sons, Bromley-by-Bow, London, E.3; P. Storrie, foundry foreman, Wolseley Motors, Limited, Birmingham; H. Taylor, foreman coremaker, Parker Foundry, Limited, Derby; D. Turner, metallurgist, G. & J. Weir, Limited; H. Turner, patternmaker, Spencer & Cook, Stalybridge; T. Wallace, iron moulder, Glenfield & Kennedy, Limited; G. Ward, moulder, Beyer, Peacock Company, Manchester; W. Ward, patternmaker, G. & J. Weir, Limited; J. H. Watson, foreman moulder, Hopetoun Steel Works, Bathgate; T. C. Wilson, assistant foundry foreman; W. Yuill, moulder, G. & J. Weir, Limited.

As Associates.

T. J. Bird, technical assistant, Hill, Robinson, Limited, West Bromwich; L. Boyle, assistant works analyst, N.E. Marine Engineering Company, Wallsend-on-Tyne; B. W. Cunningham, moulder, Consett Iron Company; N. F. Douglas, moulder, Clyde Alloy Steel Company; J. W. Gill, steel coremaker, J. Cook, Sons, Washington; H. G. Greenhouse, ironfounder, General Electric Company, Witton; E. Henderson, moulder, Consett Iron Company; W. Henderson, jun., iron moulder, Heaton Foundry Company, Heaton Junction; W. Howe, apprentice moulder, A. Morris, Sunderland; A. R. D. Kirby, jun., steel moulder, J. Cook, Sons & Company, Washington; J. T. Morris, patternmaker, J. Evans & Company, Wolverhampton; G. McFarlane, apprentice coremaker, A. Morris, Sunderland; M. Smith, patternmaker, Wallsend Shipping & Engineering Company; T. W. Trayherne, foundry ratefixer, General Electric Company, Witton; and J. P. Young, moulder, T. White & Sons, Paisley.

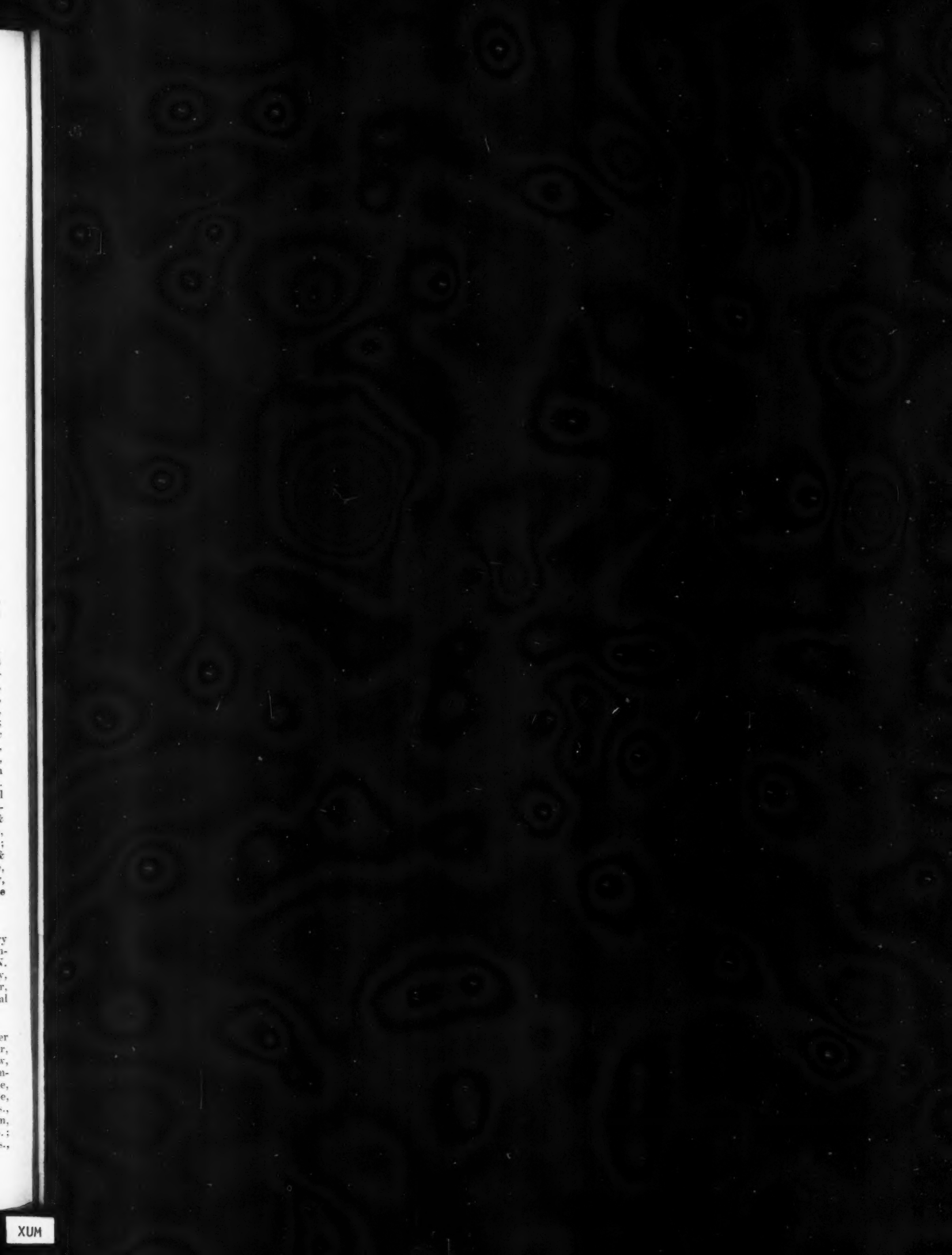
Additional List.

As Members.

Miss C. Morris, secretary, Coleman Foundry Equipment Company; H. W. Mould, ironfounder, A. H. Mould & Sons, Walsall; N. McManus, M.B.E., ironfounder, Argus Foundry, Limited, Thornliebank; B. P. Shenton, director, B. P. Shenton; T. J. Wragg, metallurgical chemist, T. L. Hale, Limited, Tipton.

As Associate Members.

E. C. Barker, foundry foreman, C. F. Barker & Sons, Coventry; W. Barnes, ironmoulder, J. Pollard & Sons, Burnley; H. O. Law, foundry foreman, John Fowler & Company, Attercliffe, Sheffield; S. B. Poole, mechanical draughtsman, Whitehead & Poole, Radcliffe; J. S. Shinner, foreman, Vowles Bros., West Bromwich; J. S. Steele, foundry foreman, Federated Malay States Railway, F.M.S.; C. D. Vowles, Junr., ironfounder, Vowles Bros., West Bromwich.



High-Duty Cast Irons.

By A. E. McRae Smith, M.A.

(*Continued from page 60.*)

Steel-Mix Irons Classified.

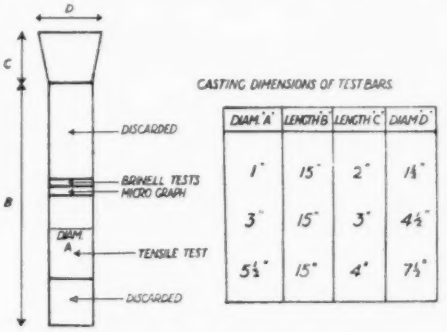
The simplest method is by the use of steel-mix irons. These may be broadly divided in groups as follow:—(1) Irons with a total carbon content of 2.8 to 3.3 per cent. with silicon percentages ranging between 1.6 to 2.5 or even 3.0 per cent.; (2) those with a total carbon content over 3.3 per cent. and with silicon from under 1 per cent. upwards, and (3) straight steel-mix irons with over 40 per cent. raw steel in the cupola mix, with total carbon 3.0 per cent. and under with silicon less than 1.4 per cent. Such irons are exceedingly strong with a composition such as 2.8 per cent. total carbon and 1.2 per cent. silicon derived from 50 or 60 per cent. steel scrap, and it is possible to obtain tensile tests on machinable 1 in. diameter bars of over 24 tons per sq. in., but such irons are at present unreliable and do not cast sound, chiefly on account of their very short freezing range, even when treated with calcium silicide. Therefore such irons have been excluded from the present series of tests.

Classification of Special Irons.

In addition to the above there must be included in this survey of high-duty cast irons the following:—(4) Nickel irons with and without the addition of steel scrap in the mixture; (5) nickel-chrome irons with and without the addition of steel scrap; (6) special process irons such as those made by the Lanz Perlit process; (7) Corsalli process and double refining process and the like, but these are not straight cupola-melted irons, and (8) high-percentage alloy irons such as "No-mag" and non-corrosive austenitic cast irons.

Potentialities of Steel-Mix Irons.

Adverting to the straight-carbon steel-mix irons, No. 1 is that which calls for special attention because, with the second class, namely, straight steel-mix iron with over 3.3 per cent. total carbon, the use of steel scrap in the cupola seems to be unnecessary except for silicon and phosphorus reduction. Steel scrap added to the cupola in high percentages can produce a very good grade of cast iron provided the elements silicon, phosphorus and manganese are suitably regulated to the section, mass, intricacy and utility of the casting being produced. Steel scrap thus added to the cupola-burden certainly helps to reduce the size of the graphite particles or flakes in the resulting casting, presumably by virtue of the fact that there are a smaller number of graphite nuclei in the initial charge, and if used in large proportions it will also considerably reduce the total carbon present. With such mixtures as that shown as No. A-1 in Table I it is possible regularly to make cast irons which will give good tensile-tests, and the employment of such mixtures results in cheap metal from the cupola spout. Steel scrap can usually be purchased at a price not exceeding that of machinery cast-iron scrap, and as no refined or special, and therefore high-priced iron is required in the mix, cheap high-duty castings result.



CASTING DIMENSIONS OF TEST BARS.

DIAM. 'A'	LENGTH 'B'	LENGTH 'C'	DIAM 'D'
1"	15"	2"	1¼"
3"	15"	3"	4½"
5½"	15"	4"	7½"

FIG. 1.—FORM OF TEST-PIECE USED.

In using such mixtures a reasonable balance must be maintained between the total-carbon percentage and the silicon percentage, and for every 0.1 per cent. reduction in total carbon, the ideal increment in silicon seems to be 0.25 per cent., taking as the standard composition 3.0 per cent. total carbon and 2.0 per cent. silicon when dealing with 50 to 60 per cent. steel-mix irons. If the total carbon is lowered too much without an increase of silicon content, then one gets a stronger iron, but, unfortunately, one which has very poor casting qualities, unless handled at temperatures which are outside the range of even the best cupola practice. It is useless to make relatively high-tensile irons, unless these have equally good casting properties.

High-Duty Iron Defined.

This raises the question of how one should define a high-test or high-duty iron. In the author's opinion, it should be an iron of equally high-tensile strength, through a large range of sections and masses. It is of little avail to say that a particular iron will give a tensile strength of 20 tons per sq. in. in a 1-in. section, if it only gives 13 tons per sq. in. in a 5½-in. section, whereas it is worse still to say that an iron possesses a strength of 14 tons per sq. in. in a 1-in. section, if it only shows 6 tons per sq. in. when tested from the centre of a 5½-in. section. Much better to say than an iron will test, say, 14 tons per sq. in. in a 1-in. section, but will only drop to 12 tons per sq. in. when cast under the same conditions in a 5½-in. section.

Table I shows various irons which have been produced from various mixtures to provide comparisons with mixture A-1, including nickel, nickel-chrome and also cupola-melted irons cast in preheated moulds by the Lanz Perlit iron process. These tests have been commenced with the idea of ascertaining ways and means of producing irons which will have the same tensile strength, hardness, machinability and utility in a large section or mass as in a small section or mass.

All the tests have been carried out under exactly comparative conditions, with cupola-melted metal in bulks of 30 cwts. per ladle. Each series of test-bars from each composition have been cast in triplicate from the same ladle of metal. The bars have been cast vertically in dry-sand moulds, and the exact dimensions and conditions of examination and testing are as laid down in Fig. 1. Each test-bar has been tested after machining to 0.564 in. dia. (*i.e.*, 0.25 per sq. in. sectional area), irrespective of the casting size, and the positions have been identical in each case. It is rather unfortunate that 5½ in. was chosen as the largest diameter instead of 6 in., but this was on account of some previous and comparable work having been carried out under the same conditions. In each case the phosphorus-content aimed at was approximately 0.5 per cent., but unfortunately, owing to restrictions in the raw material available, this element varies rather more than one would have liked in such work. In the iron alloy and Lanz series, the figures given in Table I speak for themselves, but these will be dealt with later.

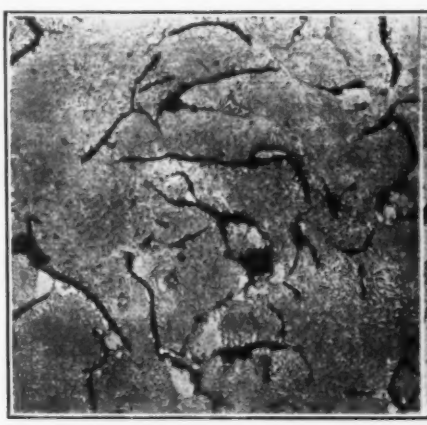


FIG. 2.—SAMPLE A-1.

FIG. 3.—SAMPLE B-3.

FIG. 4.—SAMPLE C-6.

All taken from the centre of 5½-in. bars at 200 dias.

Cast B-3, C-6 and D-4 show that with straight irons, even with comparatively low silicon-content, there is a great drop in the strength of the centre of the 5½-in. test-bar—in fact C-6, with 2.10 per cent. silicon, only gives a little over 6 tons per sq. in. in the 5½-in. section, although giving 14½ tons in a 1-in. section. When one realises that there are many irons being cast to-day giving only 9 to 11 tons per sq. in. on a 1-in. section bar, it is no wonder that the engineer insists on retaining 1.5 tons

per sq. in. as the basis for his calculations. Cast A-1 shows a cheap iron with good casting properties which has much greater strength in large sections than non-steel-mix irons. The figures quoted in Table I really favour the non-steel-mix irons, as the remelt used throughout all the experiment has been derived from steel-mix irons. Such a mix as No. A-1 can readily be applied to quite thin sections and castings of small mass by increasing the silicon and keeping the total carbon as constant as possible. Castings from such an iron ore are very readily machinable, and yet they take a good finish in massive sections. For normal sections of, say, ¾ in. up to 3 or 4 in. through, a silicon-content of 2 to 2.2 per cent., with total carbon 2.9 to 3.0 per cent., gives excellent results.

Low-silicon irons with less than 3.2 per cent.

TABLE I.

Sample No.	Details of mixtures.	Analyses of test bars.							Tensile tests. Machined 0.564 in. dia.				Brinell hardness.		
		T.C. %	Si %	S %	P %	Mn %	Ni %	Cr %	1 in. dia. Tons/ sq. in.	3 in. dia. Tons/ sq. in.	5½in. dia. edge. Tons/ sq. in.	5½in. dia. centre. Tons/ sq. in.	On 1 in. dia. at centre.	On 3 in. dia. at centre.	On 5½in. dia. at centre.
A–1	10% Burn pig-iron .. 10% Northants, 6% silicon 10% Hematite, 10% silicon 20% Remelt from same mix 50% Mild steel scrap ..	2·94	2.12	0.14	0.50	0.75	—	—	20.8 20.2 20.9	14.1 14.7 14.2	15.3 14.9 15.4	13.9 14.1 14.3	207	207	196
B–3	20% Hematite No. 1 .. 10% Phosphoric iron .. 20% Carron 1.5% silicon 50% General remelt ..	3.31	1.81	0.14	0.63	0.72	—	—	14.9 15.8 15.2	11.4 11.1 10.7	12.3 12.4 11.9	9.0 8.7 8.8	207	179	170
C–6	30% Burn pig .. .. 20% Phosphoric iron .. 50% General remelt ..	3.35	2.10	0.09	0.72	0.69	—	—	14.6 14.8 15.1	8.4 8.9 8.2	10.2 10.1 10.8	6.2 6.8 6.6	207	163	131
D–4	50% Carron 1.2% Si .. 50% Low silicon remelt ..	3.20	1.21	0.10	0.51	0.91	—	—	16.1 15.2 15.6	11.4 11.8 11.2	12.9 13.3 13.3	10.5 11.0 11.1	207	187	187
E–2	40% Carron, 1.5% Si .. 40% Low silicon remelt .. 20% Steel scrap .. .. 0.5% Nickel silicon ingot ..	3.14	1.23	0.15	0.52	0.72	—	0.49	17.6 17.2 16.9	12.8 13.0 13.0	14.0 14.4 14.5	11.8 12.0 12.0	207	207	187
F–5	20% Carron, 1.2% Si .. 60% Low silicon remelt .. 20% Steel scrap .. .. 1.0% Nickel silicon ingot	3.24	1.08	0.16	0.49	0.64	—	0.95	20.8 20.6 20.1	16.4 14.8 15.3	16.4 16.8 16.3	14.1 13.5 13.7	241	217	217
G–8	20% Carron low, 1.2% Si 60% Low silicon result .. 20% Steel scrap .. .. 1.75% Nickel silicon ingot	3.22	0.98	0.12	0.56	0.87	—	1.64	22.1 23.1 22.6	15.8 15.3 16.1	16.3 15.9 16.5	14.8 14.5 14.3	255	228	217
H–13	10% Hematite, 10% Si .. 20% Carron, 1.2% silicon 40% General surplus melt 30% Steel scrap	3.11	2.03	0.09	0.45	0.68	—	1.04	15.8 16.5 16.8	12.6 13.1 13.7	13.7 13.5 14.2	11.1 11.6 10.9	217	207	196
I–14	10% Northants, 6% silicon 20% Burn No. 1 .. .. 20% General remelt .. 50% Steel scrap .. .. 1% Nickel silicon ingot ..	3.06	1.54	0.13	0.39	0.72	—	0.93	16.2 16.7 16.6	13.4 13.2 13.3	14.1 13.7 13.9	12.6 12.5 12.1	217	187	187
J–15	20% Burn No. 1 pig .. 10% Hematite, 10% Si .. 30% General remelt .. 40% Steel scrap .. .. 1.0% Nickel silicon ingot	3.16	2.01	0.09	0.47	0.94	0.95	—	15.9 16.1 15.7	13.0 13.0 13.0	13.1 12.2 12.7	11.1 10.8 11.6	207	196	187
K–10	40% Carron, 1.2% Si .. 40% Pig iron 1.0% Si .. 20% Steel scrap .. .. 1.25% Nickel silicon + ferro chrome	3.28	0.84	0.13	0.29	0.64	1.15	0.55	White Iron	14.6 15.4 15.3	15.2 14.7 15.3	13.4 13.0 13.2	—	241	228
L–11	30% Carron, 1.2% silicon 30% Low silicon remelt .. 20% Burn No. 1 .. .. 20% Steel scrap .. .. 1·5% Nickel silicon+ferro chrome	3.36	1.40	0.12	0.33	0.87	1.42	0.25	17.8 18.2 18.0	11.7 10.9 11.4	12.4 11.8 12.6	9.8 10.4 10.1	228	196	196
M–16	30% Carron, 1.2% silicon 30% Low silicon remelt .. 10% Burn No. 1 .. .. 30% Steel scrap .. .. 1.0% Nickel-silicon ingot+ ferro chrome	3.32	1.26	0.12	0.39	0.75	1.08	0.32	18.6 19.1 18.4	13.2 13.5 13.4	14.7 14.4 14.4	12.1 11.9 12.2	241	228	207
O–7* Perlit	20% Carron, 1.2% Si .. 35% Low silicon remelt .. 45% Steel scrap	3.20	0.66	0.13	0.46	0.78	—	—	18.3 18.3 18.6	17.2 16.4 17.5	18.0 17.7 17.5	16.9 16.8 16.6	217	207	207
P–12*	30% Carron, 1.2% Si .. 20% Pig iron, 1.0% Si .. 30% Low silicon remelt .. 20% Steel scrap	3.28	0.93	0.15	0.36	0.84	—	—	16.8 17.1 17.0	15.6 15.2 15.8	15.9 16.2 15.9	13.4 13.8 13.5	217	196	196

* Lanz perlit.

total carbon, because of their very short freezing-range, are inclined to be unsound and to be very shrinky in nature. Irons like mix A-1, and in fact all high-duty irons, should be poured at the highest possible temperature. Foundrymen often have a certain amount of fear when casting large castings hot, but, providing the moulding practice is good and a sufficiently refractory mould-dressing has been used, every mould should be cast as hot as possible. Low-temperature casting of steel-mix irons as well as low-silicon non-steel-mix irons invariably leads to drawn castings and blowholes.

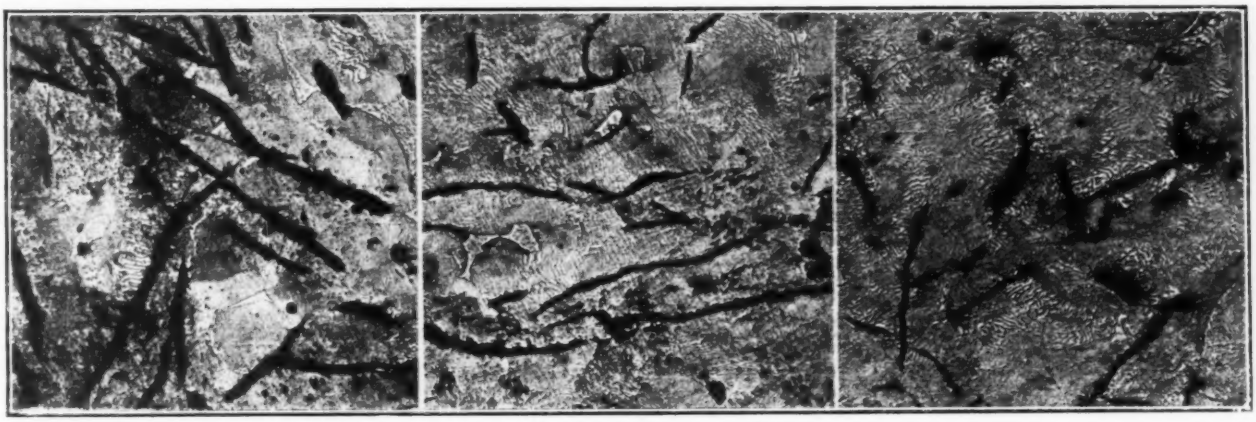


FIG. 5.—SAMPLE D-4. FIG. 6.—SAMPLE E-2. FIG. 7.—SAMPLE F-5.

All taken from the centre of 5½-in. test-bars at 200 dias.

Cupola Practice for High-Duty Iron.

With regard to cupola practice for such mixtures, this part of the process is very important. Of necessity all charge material must be accurately weighed and steel scrap should be as far as possible of uniform size and the mass and section should not be too small. Melting must be rapid, else the carbon pick-up will be excessive. This rapid melting is easily accomplished by careful blast-control. For ordinary cupolas, the type advocated should be that which will allow of low-pressure blast being utilised. It should be possible very carefully to control the volume of air entering the tuyeres by regulation of fan-speed controlled by checking the volume of the air by means of a pilot tube. When hot metal—that is, over 1,400 deg. C.—is required in the first few charges, then a high coke-bed should be used, but even for the largest percentage of steel scrap, say 60 per cent., the charge-coke should not exceed 12 per cent. Individual charges should be small, and when working without a receiver at least three charges should be tapped at a time.

Provided this type of metal is tapped at a sufficiently high temperature it will last well and can readily be transferred from the crane-ladle to hand-shanks for the casting of small work. Mechanical charging is much more economical than hand charging and gives equally good results provided the size of individual charges are small enough. This is an economy which, where possible, should be practised in every modern foundry and thus save much double handling. The height of the coke should be measured on each occasion before beginning to charge metal.

Carbon Control.

Cupola carbon control is difficult, and much research is needed on this point. One outstanding feature in this respect is the fact that slow-melting gives high carbon and quick-melting gives low carbon from the same steel-mix. It is equally true that the carbon-contents of the original mixture often bear little relation to the final result. For high-grade irons it cannot be too often emphasised that hot and rapid melting is essential. Excess air gives oxidised and cold metal. Lack of air gives slow melting, high carbon pick-up and dirty metal.

The Newer Melting Methods.

For most foundries the cupola is still the standard and the most economical furnace for the production of grey cast iron. Already steps are being taken in the right direction on the Continent for producing high-quality cast iron by other means than in the cupola. There are methods in use of superheating the metal, as, for instance, double-processes, involving the use of the electric furnace for the superheating and refining process, and then there are furnaces like the Buess and the Brackelsberg working on pulverised fuel, and it is to be hoped that these furnaces will be successful and prove economical in the production of high-grade irons. While these newer furnaces and processes are being tried out it is up to the foundryman to improve his cupola practice in the production of high-test irons. Such results as speeding up the melting-rate without increasing the cupola diameter and reducing the weight of charge-coke without lowering the tapping temperature or the quality of the iron should be earnestly sought.

The Poumay Cupola.

Many attempts have been made to improve cupola practice by means of alterations in cupola design, and with standard-type cupolas the more important points are: correct ratio of height of cupola to sectional area; correct ratio of tuyere area to melting-zone area; shape, size, simplicity and adaptability of tuyeres; wind-belt and pipe lines. Amongst novel designs of cupolas, one which deserves some attention is that of Mr. Poumay. The writer has had personal experience with this type of cupola for some eighteen months, and finds that it is a very good proposition for melting steel-mix cast irons, where rapid melting and high tapping-temperatures are as important as fuel

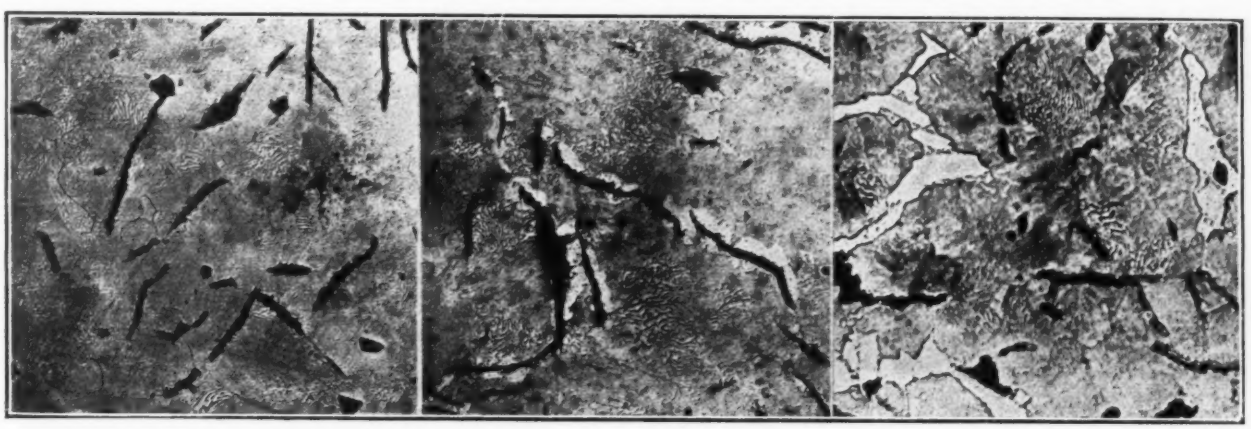


FIG. 8.—SAMPLE G-8. FIG. 9.—SAMPLE I-14. FIG. 10.—SAMPLE K-10.

All taken from the centre of 5½-in. test-bars at 200 dias.

economy. With 40 to 60 per cent. steel scrap cast-iron mixtures it is possible to melt with 10 per cent. charge coke and get metal at 1,400 to 1,450 deg. C. tapping temperature. With ordinary phosphoric irons this cupola is capable of giving a good commercial iron with a melting ratio of 6 to 7 per cent.

However, in the writer's opinion it is false economy to try to save even a few cwts. of coke per day if it is obtained at the expence of a lower tapping-temperature and melting-rate. Also any comparisons drawn between cupolas should always state the exact conditions of metal mixture, approximate size of material charged, weight of charges and, most important of all, temperature of the metal at the spout.

Theory of the Poumay Cupola.

The principle involved in the Poumay system is based on allowing only enough air to enter at the main tuyeres to burn the coke to carbon monoxide, instead of carbon dioxide, at the fusion zone. These main tuyeres consist of melting and preparing tuyeres of such a shape as to give a spiral motion to the air blast. At about 4 to 6 ft. from the charging door of the cupola (the distance depending on the height of the charging door from the main tuyeres), a series of blast pipes arranged in a two-throw spiral convey additional air higher up the cupola burden to convert carbon monoxide to carbon dioxide. The spiral formation allows of the gradual burning of the CO to CO_2, and thus getting a gradual preheating of the descending charges. The novel features are actually the shape and size of the main tuyeres, which are augmented by an equal number of small tangentally-branched tuyeres, together with the spirally-arranged auxiliary or regenerating tuyeres, through which the amount of air passing can be regulated. In this type of cupola, the ratio of total tuyere area to area at melting zone is something like 1 to 15 instead of the normal 1 to 5 or 1 to 6 with low blast-pressure systems. The Poumay system works best at about 28 in. water gauge as against 12 to 16 in. for low-pressure blast.

On the Continent there are said to be over 400 Poumay cupolas at work, and the furnace which has been converted at Dartford has certainly paid its way, particularly indirectly, by the production of hotter metal, in less time per ton tapped with the same internal diameter. At the same time, a considerable saving in fuel has been effected, and the furnace continues to work well provided the shape and size of the tuyeres are kept constant. It is by failing in this respect that previous cupolas of a similar type have appeared to fail.

Alloy Cast Irons.

Much consideration has lately been given to alloy and special process cast irons. The chief alloying elements made use of have been nickel, chromium, copper and manganese, where used in percentages very much above the normal, might also be classed with these three elements. The author has had considerable experience with nickel irons and their properties, and the results of several tests are given in the graduated-diameter tensile tests given in Table I.

Nickel, as is well known, is rather similar to silicon in its effect on cast iron, yet in practice it is really different. True, it tends to precipitate graphite, but the precipitated graphite is invariably much smaller in character and the matrix of any iron to which 1 to 1.5 per cent. nickel has been added is always more uniform than that of a similar iron without nickel addition. In order to get the best results it is necessary to reduce silicon in the ratio of about 0.1 per cent. for every 0.3 per cent. of nickel added. Low-silicon nickel irons are very useful in an attempt to obtain that *same-all-through* objective, and with low silicon and the addition of 1 to 1.5 per cent. nickel considerable improvements in the strength of large sections can be effected.

Nickel Irons.

Referring again to Table I, it will be seen that, while 0.5 per cent. nickel (E-2) has not much effect on the 5½-in. test-bars, 1 and 1.5 per cent. nickel additions show a considerable raising of the tensile strength in such sections. It must be remembered that the 1-in. diameter test-bars only weigh a few pounds, and in straight carbon irons 1.2 per cent. silicon is about as low as one cares to go with medium total carbon if the bar is to be free from cementite and be easily machinable, whereas series G-8 shows that with 1.0 per cent. silicon and 1.5 per cent. nickel it is possible to get a much stronger iron, and although the Brinell hardness number for such an iron is considerably higher than normal, yet it machines quite easily. In fact, nickel irons machine very well even up to 260 Brinell. Series H-13, I-14 and J-15 show the result of attempts to produce iron containing nickel, but high in silicon and made from steel-scrap mixtures. Strange to say, as far as these tests have gone, the nickel irons have not shown up as being very strong in the smaller diameters, but the percentage drop in tensile strength over the range of diameters is less than with the stronger irons. Therefore, with nickel, always reduce the silicon whether using much or little steel scrap.

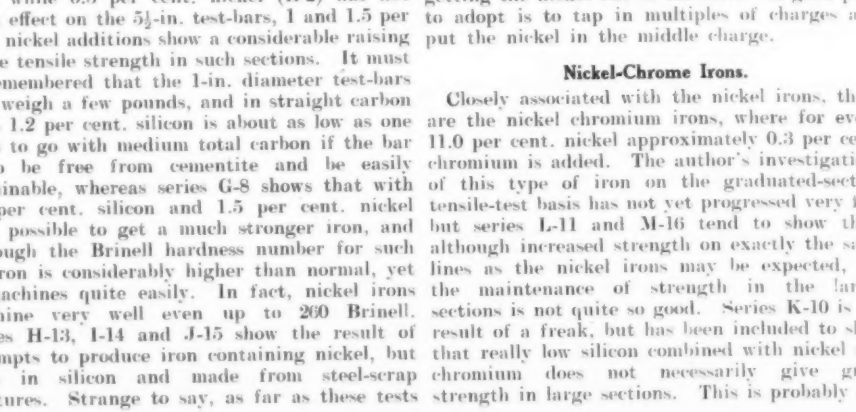
Apart from the stronger irons for massive castings, the addition of 1 to 2 per cent. of nickel to important light castings can be made a commercial success, the extra cost of the nickel being more than recovered by the subsequent cheapening of the machining process and the elimination of scrap due to dirty castings and hard spots, particularly at sharp edges. Molten cast iron, containing, say, 1 to 1.5 per cent. nickel, seems to run very well, and it would be interesting to get a comparison of the viscosity of such irons with normal irons. Nickel used correctly, by virtue of the power which it has to give good matrix structure and freedom from porosity in heavy sections, is likely to prove a valuable adjunct to the production of cast iron. The additional cost of adding 1 per cent. nickel to cast iron works out at about 35s. per ton of molten metal, but this can in most cases be offset by the entire absence of expensive irons and by the use of steel scrap in the mixture.

Adding Nickel to Cast Iron.

Nickel addition is best carried out by direct charging to the cupola in the form of pure nickel or nickel-silicon alloy, which can be obtained in convenient ingot form. For small quantities of metal it can also be added in the form of shot to the metal stream or to the ladle, but such ladle additions must lower the temperature of the bulk and are always rather messy and unsatisfactory. When added direct to the cupola one need have no fear of not getting the nickel out in the melt. A good plan to adopt is to tap in multiples of charges and put the nickel in the middle charge.

Nickel-Chrome Irons.

Closely associated with the nickel irons, there are the nickel chromium irons, where for every 11.0 per cent. nickel approximately 0.3 per cent. chromium is added. The author's investigations of this type of iron on the graduated-section tensile-test basis has not yet progressed very far, but series L-11 and M-16 tend to show that, although increased strength on exactly the same lines as the nickel irons may be expected, yet the maintenance of strength in the larger sections is not quite so good. Series K-10 is the result of a freak, but has been included to show that really low silicon combined with nickel and chromium does not necessarily give great strength in large sections. This is probably due to the fact that a certain amount of free cementite persists in these large sections, notwithstanding which fact the material is reasonably easily machinable. The conclusion which at present can be derived from these preliminary tests is that for strength in mass section the addition of chromium is unnecessary when nickel with reduced silicon will give better results. Where chromium may be of considerable value is in the formation of a more stable form of pearlitic matrix, with consequent better wearing qualities and heat-resisting qualities. Future research alone can tell us this.



Figs. 11 and 12.—Lanz Perlit (Sample O-7).
Taken from the centres of 1-in. and 5½-in. test-bars respectively × 200 dias.

Lanz-Perlit Irons.

Apart from the two types of alloy cast irons described, where the additions are mainly made for increased strength, uniformity of structure, machinability and soundness, there are the corrosion-resisting types leading up to the austenitic types, where not only nickel and chromium, but also copper, are used as the alloying constituents. Coupled with this group we also have the non-magnetic alloy irons, all of which are likely to have a great future. However, these irons are rather outside the scope of this Paper. Special process irons, heat-treated irons, superheated irons and double-process irons are also occupying much attention, the main object of all such processes being to obtain increased strength per area of cross section and to minimise the effect of diversity of section.

The only one of those processes of which the writer has had any experience is the Lanz Perlit iron process, in which irons low in silicon and

moderately low in total carbon are cast into moulds heated to a predetermined temperature in such a way as so to retard cooling that the irons are totally pearlitic in structure and free from cementite in spite of their composition. Series O-7 gives the results of a typical cast of Lanz Perlit iron, and it is remarkable, yet to be expected from the nature of the process, that this gives the smallest section-gradient drop of all the irons tested. Lanz Perlit does not claim to yield a high-tensile iron, but it does yield a metal which is more nearly the same all through than any other cast iron the author has yet handled.

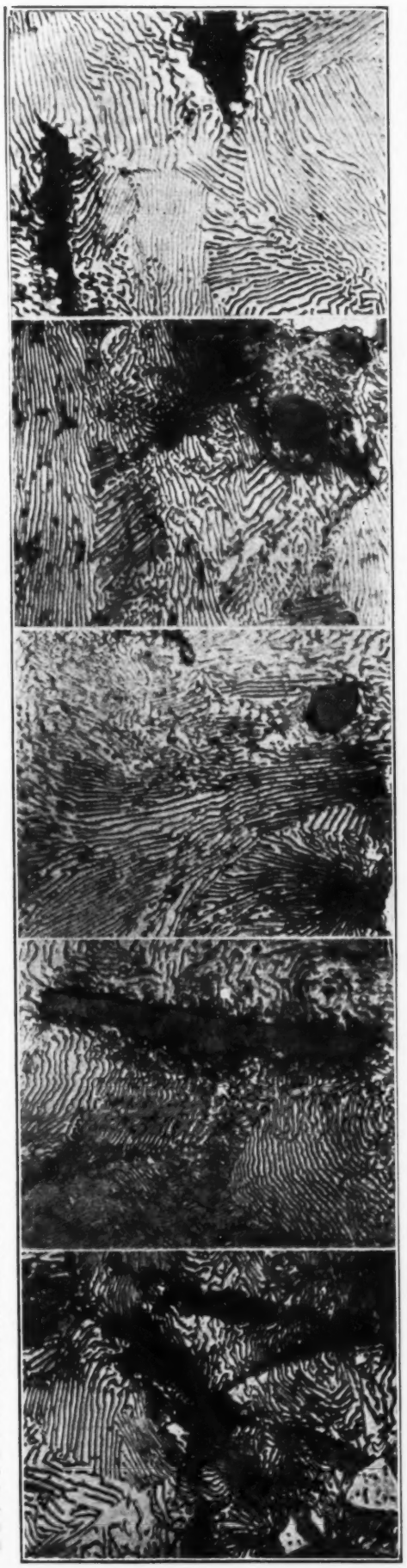
Series P-12 gives another Lanz iron, the range of which is only suitable for light castings, but which even then shows a remarkably low section-gradient drop. The Lanz irons tested with this series are really much too high in phosphorus for the usual specification, but this has been done intentionally to keep them in line with other irons of the group.

It is unfortunate that the Lanz process is rather cumbersome, but once men get accustomed to it, it is wonderful what results can be achieved. This process is remarkably suitable for lumpy castings which have to be machined into an intricacy of holes and passages, having to withstand high gaseous pressure, and it is now establishing a reputation all over the country of its utility for high service jobs. When it is possible to have furnaces designed to give sufficiently highly-superheated metal economically which can be subsequently cheaply treated for carbon equalisation, perhaps followed by cheap and effective heat treatment, then metallurgists may find alloys which have the properties of true cast iron but which do not suffer from section-gradient tensile-strength drop. Until then the Lanz process certainly appears to nearly fill the bill.

Light on the Test-Bar Problem.

The series of section-gradient tests tabulated in this Paper are of necessity very incomplete and only an indication of what a variety of series of tests could be carried out on this direction, but they do give a line to that vexed problem of the misleading results to be obtained from small-diameter separately-cast test-bars.

Cast-on test-bars are often advocated, but although more representative of a casting, they are often awkward to deal with in the machine shop. By cast-on test-bars, it is meant that the test-bar will take the form of an additional flange or such projection and be integral with the casting, and not merely a small-diameter bar attached to the casting by means of a runner or runners. It seems advantageous to consider grading the section of runner-attached test-bars to the section and mass of the casting and so endeavour to get a better idea of the strength of the casting. Some may say that the strength of even heavy-section test-bars is no indication of the soundness of the casting, and rightly so, but if one cannot first fortell with a reasonable degree of accuracy the strength and grain density of a plain bar of heavy section, how can one expect to foretell the soundness or unsoundness of an intricate casting? After all, the intricate casting of divergent section is only an elaboration of the heavy section bar, and if one studies every casting on its merits and provides adequate means of self-feeding and controlled cooling, surely one can produce castings which any inspector would be allowed to cut up and take his test-bars therefrom. Unequal masses both of metal and core must be studied from the point of view of the laws governing the solidification of the alloy used, and if one can modify or simplify these conditions by the use of alloyed irons by the Perlit process or simply by the choice of suitable compositions of steel-mix irons, then the use of high-duty cast irons will give a new impetus to the grey cast iron industry.



Let metallurgists know the cast-iron alloy completely and know what it is capable of, for unless they know all its properties absolutely in simple examples like the sectionally-graded test-bars, the properties of which have been briefly outlined, how can they expect to know the reasons for their success or failures in complicated castings? Again, how can founders hope to get the engineer to raise his calculating strength from 1.5 tons per sq. in. in face of the figures presented, unless they can persuade him that increased section in cast iron does not necessarily mean increased strength, which is in itself a confession of their partial failures? The time must come when a drastic revision of tests is called for in specifications for various grades of cast iron, and only when that time arrives can we expect engineers to be persuaded to modify the 1.5 tons per sq. in. figure.

Iron and Steel Manufacturers and Proposed Tariff Truce.

The Executive Committee of the National Federation of Iron and Steel Manufacturers, at a meeting held to consider the proposals for a tariff truce, passed the following resolution, which has been communicated to the Prime Minister, the Lord Privy Seal and the President of the Board of Trade:—

"That this Federation views with grave apprehension the proposals for a tariff truce, which surrender the freedom of action of this country in the exercise of negotiating power to secure the general reduction of tariffs at present operating to the grave disadvantage of this industry throughout the world. While securing the advantages of the present position to foreign competitors in this country, the proposals would destroy the possibility of strengthening British competitive power in world markets. In the opinion of this Federation, under present world conditions such proposals will prove disastrous to the British iron and steel industry and preclude all possibility of an early solution of the unemployment problem in this country."

FIG. 13.—A SERIES OF MICROPHOTOGRAPHS TAKEN AT 800 DIAS. FROM THE OUTSIDE TO THE CENTRE OF A 5½-IN. TEST-BAR MADE FROM LANZ PERLIT IRON.

London Iron and Steel Exchange.

Annual Meeting.

The annual meeting of the London Iron and Steel Exchange was held at the Great Eastern Hotel on Tuesday, January 21. Mr. Watson Slack, chairman of the Committee, presided, supported by Mr. James Whitby, chairman of the directors.

In reviewing the events of the year, Mr. Watson Slack explained that the Committee had decided to hold a monthly luncheon, at which addresses on matters concerning the trade would be given. These luncheons would be followed by meetings of the Exchange. They had held two very successful luncheons, at which addresses by Mr. Percy Donald and Mr. H. J. Skelton had been given. A number of successful arbitrations had been held during the year, and the members of the iron and steel trades were making an increasing use of the Exchange Court of Arbitration, which saved them the trouble and expense of legal fees.

Mr. H. J. Skelton referred to the fact that for the past two years a Cabinet Minister had attended their annual dinner. He thought that the organisation of the Iron and Steel Exchange was of considerable value to the trade. It was known to Government departments, and might be of considerable use to members when legislation affecting their business was under consideration. Even at the cost of some sacrifice he urged the members to support the organisation, which it might be impossible to rebuild if it were once allowed to collapse.

Mr. A. E. Webster supported Mr. H. J. Skelton, and said that from personal experience he knew that a Government department would listen to organised bodies when they would not listen to individuals.

The meeting closed with a vote of thanks to the chairman, Committee and directors.

XUM

The Cooling and Solidification of Metals.*

By A. Campion, F.I.C. (Consulting Metallurgist).

A very large amount of care and attention is devoted to the adjustment of the chemical composition and selection of materials charged into the furnace in the majority of founders, but although this is a matter of prime importance, the benefit may be quite easily lost in later stages of the production of the casting. It is surprising that comparatively so little attention is devoted to the conditions of cooling and solidification in many foundries. The casting may be totally ruined by unsuitable conditions during this stage of the process.

It is possible to distinguish between two types of casting, the first essentially the province of the founder, where the casting itself represents the finished product having, apart from after-treatment, its properties determined during its solidification. The other type represents material for a starting point of articles produced by mechanical-treatments such as forging or rolling. In many cases such work is necessary not solely for the shaping of the material but also to remove imperfections or refine the structure in order to bring the material up to a desired standard.

Modern industry demands the shortening of these processes and a reduction of the number of operations. It is, therefore, the aim to produce castings of higher quality to replace the more costly forged articles. This has to a certain extent been achieved. The founder is mainly concerned with the effects of the casting process upon the constitution, structure and properties of the resulting metal, and as the constitution and structure of any casting of a particular metal or alloy is very largely determined by the rate of cooling and the rate of solidification in the mould, it becomes a matter of the utmost importance that the cooling should proceed at the correct rate. The cooling rate for the majority of materials is the most rapid possible without causing cracking, warping, etc. As a general rule, metal cast in chill moulds has a finer structure than the same metal cast in a sand mould. This is due to better conduction and more rapid solidification. This, however, is not a general rule, there are exceptions, for some metals undergo critical changes or transformations during cooling, such as cast iron; for instance, rapid cooling causes the suppression of the change from combined to free carbon, and a white iron is produced.

Apart from the mould or local chilling, the rate of cooling can to a certain extent be controlled by the temperature of the metal at the time of casting. A very high-casting temperature may so reduce, or even exhaust, the thermal capacity of the mould that solidification takes place so gradually that segregation occurs with the production of a very coarse structure. Therefore the casting temperature should be as low as possible consistent with the necessary degree of fluidity to permit casting and the filling of the moulds.

The lecturer here explained the mechanism of solidification and crystallisation with the aid of a number of slides. He pointed out that the actual size of the crystals formed was accidental, being dependent upon the cooling rate. If the rate be rapid, it restricts crystal growth. Crystallisation always commences from a few nuclei from which the process then continues rapidly.

A rapid rate of cooling is desirable through the freezing range, but it is necessary to have regard to contraction stresses causing warping or even fracture if the outer-layers of the metal have become solid and rigid with the interior portions still liquid. All metals undergo some change in volume on solidification, so that stresses are bound to be set up if the interior portion tries to change its volume as the rigid envelope or shell will resist the change. The manner of cooling has considerable influence in this action, if the relative rates of cooling of the thick and thin parts of the casting can be equalised, the cooling velocity may be largely increased without doing damage.

The first requirement in a casting is soundness, and this quality is very intimately related to volume changes due to temperature, for it must be noted the volume of a substance depends on its temperature and pressure. At any particular temperature a mass of metal occupies a definite volume, *i.e.*, its density is a specific quantity, and this is the real or true density. At ordinary temperature the density of the solid metal is usually rather less, that is, the volume of the casting is a little greater than would be expected from the density of the metal. This may be due to the occlusion of gases, the presence of cavities or separated matter. In a perfectly sound casting the two values would be equal.

It is unfortunate that, with the exception of steel and cast iron very little reliable data is available in respect of change of volume of metals in the liquid state and in the region of the freezing point. As regards solid metals, the change of volume data is rather more plentiful and reliable. The allowances made by patternmakers appear to be fairly correct.

Commercial castings are practically never in a state of stable equilibrium as regards temperature and volume owing to the low viscosity of the metal causing an hysterisis or friction, so that the casting cools to normal temperature before the changes are quite complete. The residual energy necessary to complete the contraction is locked up in the form of casting strain. This strain is sometimes set free during the dressing operations or later, and results in warping or cracking. This is most noticeable in the case of rapidly cooled castings. Annealing will release this strain by completing the volume changes.

The most critical time during the cooling of castings is when the metal assumes the pasty condition, the change of temperature in the liquid or solid produces a small and fairly regular change of volume. When the metal passes from the liquid to the solid or vice versa a somewhat large change of volume takes place, maybe the solid occupies more or less volume than the liquid—that is, the density suddenly changes. In the case of pure metals and certain alloys this change occurs at a definite temperature, but other alloys exhibit this change over a range of temperature.

The lecturer here, by the aid of slides and diagrams, explained the progress of solidification, changes in volume and temperature gradients in alloys and metals freezing at constant temperature with increase and decrease in volume and those freezing over a range of temperature with changes in volume. He showed how the cavity is formed in the centre of a sphere or cube and the relationship between the changes in volume and the true and apparent density.

If the mould in which a mass such as a cube was cast was quite rigid, the face would retain close contact with the first skin and the net contraction cause a cavity near the centre of the casting. If the mould were made soft and yielding, the first expansion of the skin would make the mould slightly larger and the internal cavity would be increased.

The thermal properties of the mould and the metal were dealt with in relation to the amount of the contraction. It was shown that if the mould had a high conductivity, the gross expansion was less, whilst if the metal had a high thermal conductivity the gross expansion would be greater. In the case of metals freezing at constant temperature with expansion the volume of the internal cavity would be increased by using a yielding mould of high conductivity or by using a metal having a high coefficient of expansion in the liquid and solid conditions and having low thermal conductivity. Casting at very high temperature produces a similar result. The majority of metals show contraction on freezing, but the same line of reasoning applies. The factors which influence the size of the cavity formed in a mass of metal left to cool undisturbed are:—(1) The thermal capacity of the mould; (2) the thermal capacity of the metal; (3) the coefficient of expansion of the liquid and solid metal; (4) the net contraction on freezing of the metal; and (5) the temperature of the metal at time of pouring. If all these factors could be controlled it would be possible to eliminate, or at any rate greatly reduce, the cavity; but unfortunately this is not possible, as the properties of the particular metal have to be considered and considerations other than removing the cavity arise in the production of commercial castings. The casting temperature and the nature of the mould can, however, be controlled to a considerable degree.

A casting is not necessarily drawn in the last portion to solidify, as is so often stated to be the case. It was true that some contraction occurred in the last portion to freeze, but cavities were found in portions of a casting which solidified quite early in the process. The cavities really formed at portions which were cut off from a supply of liquid metal or where feeding could not be effected. It is often stated that a casting should be designed so that the section should be regular and uniform, but this would not ensure absence of cavities or draws; as a matter of fact, a casting with a very large expanse of even section is often the most difficult to make sound. Similarly, if the whole casting cooled at the same time, soundness would not necessarily be secured, but very probably cavities would form all through the casting, giving general unsoundness and weakness. What is really required is to control the cooling, so that each layer of metal deposited follows a wave of cooling in a direction where the cavity can be segregated to where feeding can be effected. In fact, cooling should be directional, but in view of the varied size and form of castings, it is not altogether a simple matter to attain this object. Each individual casting has to be considered, but as a general rule it is laid down that the contraction should be localised at a point where there is a runner or riser containing liquid metal. Risers are very often totally inadequate on account of the small size. The most useful application of a riser is to feed portions of the castings isolated from the main freezing wave, and should be located in a position to achieve this object.

As an aid to the control of the cooling directionally the manner in which the flow of heat takes place can be considered. The form of the casting, quite apart from the type of metal or other circumstances of casting, exerts a great influence upon the resulting structure, since the shape very often determines the manner in which cooling occurs and thus determines the direction in which the maximum heat flow takes place during freezing. It is invariably the case that crystals grow along the lines of heat flow, but in an opposite direction.

The lecturer here explained, by the aid of slides, the growth of dendrites and the formation of nuclei in succeeding layers of metal as cooling in a mass proceeds and the drawing of isothermal lines.

If isothermals are drawn for portions of a casting, especially where there is a corner or re-entrant angle, it will be seen that the heat

* Extract of a Paper read before the West Riding of Yorkshire Branch of the Institute of British Foundrymen, Mr. W. G. Thornton presiding.

conducted into the mould from one cooling surface will retard the cooling of an adjacent surface. The isothermals therefore curve inwards and it follows that the metal at the corner will be the last to solidify. This metal will be liquid when the remainder of the corresponding layers has solidified, and the solid parts will tend to contract as they cool. The tendency is, therefore, to produce shrinkage cracks or draws at this point.

If isothermals can be drawn representing the cooling of a casting, and usually the general direction can be inferred from the shape of the casting and general cooling conditions, considerable assistance will be obtained in the localisation of shrinkage and the subsequent feeding positions.

Isothermals are close together where cooling is rapid and wide apart where cooling is slow, and if this is borne in mind it will permit of the sketching of the shape of the isothermals of a particular casting with considerable accuracy. The application of local chills or denseners can be more effectively accomplished if such facts are utilised.

DISCUSSION.

The PRESIDENT said Mr. Campion had put the scientific aspect of practical foundry work in as clear a manner as could possibly be done for the benefit of foundrymen who were not all chemists or scientists. He had not, however, thought Mr. Thornton altogether told them how to overcome the difficulty of shrinkage, and no doubt he would be glad himself to hear members present give their experiences in trying to deal with troubles in that matter. Mr. Campion had mentioned the use of risers and feeding heads, and indicated the manner in which they could be adapted. Was there not some other means of overcoming the difficulty from the point of taking the composition of the metal more into consideration? Another point on which Mr. Campion might possibly enlarge was that it was a well-known fact that different compositions of iron had a different range of freezing, which was a very important part of a founder's duty to watch in respect to feeding the various castings.

MR. S. W. WISE, Hon. Secretary of the Branch, said one point which he would like Mr. Campion to make perhaps a little clearer was that he had seemed to give the impression that, in his opinion, it would be better to cast at a temperature as low as was consistent with a sound casting, *i.e.*, to avoid cold shut. On the contrary, the experience of many was that the higher temperature at which they could cast iron the better. Referring to internal stresses, Mr. Wise asked for an opinion on the practice of "seasoning"—leaving a casting in the open for a time to mature. Personally, he was not sure it was so good as it was sometimes thought to be. It was very essential that all the strain should be released if possible, and he would suggest heating a casting up to 400 deg. C. and cooling slowly.

MR. F. ROWNTREE (of Bradford) asked whether Mr. Campion gave the reason for a casting having two risers of equal proportions and receiving an equal proportion of metal, only one riser would show porosity. The casting in question was a blank wheel, consisting of a 3-in. plate, with a rim round, and weighed about 3 cwt. The risers were off the plate, placed equally between the runner in the centre.

MR. BENTLEY said that in case of high-test cast irons, foundrymen were accustomed to being told to cast at the highest temperatures and with the slowest speed of cooling—which seemed rather contradictory to what Mr. Campion had said that evening, though probably he could qualify his remarks and make some further explanation on the point.

MR. BOWLING asked whether Mr. Campion could give any information on the question as to whether nickel would eliminate shrinkage?

MR. H. SAYERS asked, did Mr. Campion know of any composition of cast iron that would give the lowest possible shrinkage, if there was, they would all be very glad to hear it.

MR. A. S. WORCESTER said, on the matter of the specific gravity of the liquid and solid state as described by Mr. Campion, one thing seemed peculiar. According to natural laws the liquid contained in a cube should be heavier than the solid. When one made a solid block, it should still float in liquid iron of the same composition. In regard to Mr. Campion's directional heat wave, Mr. Worcester said he was afraid one could not very well alter it, because it had to come from where the heat was greatest, so that they were rather left at a "dead end" from that point of view. The only other way, he thought, was to overcome unequal stresses by dealing with the distribution of the liquid metal—though he supposed they had to regard cast iron really as a conglomeration of metals. Could Mr. Campion give any idea as to what could be done in the matter of filling cavities during the cooling range due to the growth of the graphite during solidification.

Author's Reply.

MR. CAMPION, replying to the points raised, said, in regard to the remarks of the chairman, what he had stated was that, consistent with obtaining the necessary fluidity to run the mould completely, the lower the temperature the better. But they had to remember that all cooling was fairly rapid. "High" and "low" were, after all, only relative terms; they were all actually high temperatures. He had also pointed out that that applied more in the case of pure metals than in alloys; but cast iron was an exception and a material which solidified over a long freezing range, and the longer the range the higher the temperature necessary to cast it in order to ensure soundness, and the only remedy was to equalise the heat. In regard to risers and feeders and methods of filling up the cavities to overcome the shrinkage, it was practically hopeless to expect to eliminate all the cavities, and one should try to remove them into some place where they could fade. Composition was germane, but there were other factors. One had to make a casting of a particular metal and had to take into account the particular properties of the materials to be used, so that factor instituted a limit on the question of composition. The freezing range was altered by composition. As a rule high-temperature cast irons, though they had a long freezing range, would freeze over a lower range than some of the lower-temperature cast irons. Those remarks perhaps answered some of the observations made by Mr. Wise. He thought it was not possible actually to get too high a casting temperature. The longer the freezing range, the higher must be the casting temperature, and in some materials with a very high casting temperature the temperature would be inconveniently high and one had to decrease the thermal capacity in the mould.

Seasoning Iron Castings.

In regard to the question of "seasoning"; he considered it was rather a waste of time. The contraction stresses which were mentioned were often relieved in the dressing-shop procedure, but leaving castings in the open air seemed to him (Mr. Campion) a very long way of doing a simple thing, and heating to low temperature would release these strains almost at once, and much more effectively, and at the same time remove any remnant of volume change which was not complete. The question had been asked by Mr. Rowntree as to why one of the risers showed porosity and the other did not. Every casting, of course, was a job to itself, and without being on the job and having knowledge of all details of the particular job it was dangerous to make any kind of dogmatic statement in answer to such a question. It was not easy to answer, but probably it was due to a trapping of the air in two currents in the metal. On the question of casting temperature, it was quite true to say cast at as high a temperature as possible because most of these special materials were high semi-steel and one had to ensure fluidity by heat or by running the casting through at a slower speed, which reduced the cavity and equalised the cooling at the different parts of the casting. In regard to the question of nickel in cast iron, that probably did reduce the total contraction to a certain extent, but it would not reduce the liquid contraction or the cavities which, after all, were the chief trouble. Nickel acted very like silicon in throwing out the graphite and therefore decreased the contraction, but one had to remember that for successful use of nickel one had to reduce the silicon and replace it by nickel, so one was first increasing the total contraction and then reducing it a little by the nickel.

The question had been asked (proceeded Mr. Campion) as to what would be a composition of metal to give the least possible shrinkage. One could easily reduce the shrinkage by reducing the silicon, but it was useless for the object in view. It was rather in the nature of one of those general questions which led nowhere, because everything depended on what the casting was and what it was for. It was better to have the shrinkage and do one's best to overcome it by feeding or running at a slower speed. On the question of the graphite between the liquid and solid state; in the liquid state there were no pores or holes in it, but after cooling down there was a certain number of cavities due to unequal cooling or slag or gas. If one took the same quantity of metal and cooled it down to room-air temperature the same volume weighed rather less because it had cavities in it, and cavities formed when it was too flat. On the question about the heat gradient, could one deal with it to cool it any other way? This was done by the judicious use of chills or by adjusting the casting temperature to try to equalise the cooling of them and drive the still-liquid portions to a part where they could be handled. There was, suggested Mr. Campion, room for much more co-operation between the designer and the founder and the patternmaker before the job was cast instead of afterwards. He believed there would be less wasters and they would all learn a great deal more and the industry as a whole would benefit.

A hearty vote of thanks to the lecturer concluded the meeting.

Metal Firm's Jubilee.

Half a century of big business in the iron, steel and metal trades is the record of Messrs. William Jacks & Company, of London, who celebrate in 1930 their jubilee year. Founded in 1880 by the late Dr. Jacks, the firm has numbered among its partners, past and present, the Rt. Hon. the late Bonar Law, P.C., J. Gray Buchanan, J.P., Stewart Barry and R. R. Walker, and in addition to having offices in Glasgow, Middlesbrough, Birmingham, Liverpool and Swansea, has its old-established branches in various parts of the world, including Bombay, Calcutta, Cairo, Karachi, Rangoon, Shanghai, Singapore, etc.

The choice of "Limpet" as a trade mark has been particularly appropriate, associated as it is with this long record of continuous large-scale effort for the promotion of British interests. "Sticking" hard at it is an essential for such continuous progress. We wish to associate ourselves with the numerous congratulatory messages which have been received from business interests located in every corner of the globe.

The "Annual Review of the Iron and Steel Trades," published by this firm and now available to our readers, is regarded in the best-informed circles as one of the most illuminating, authoritative and erudite statements of current affairs regularly originated by private enterprise.

XUM

Elasticity and Fatigue Strength of Cast Iron.

A. Thum and H. Ude have carried out some interesting experiments on the fatigue strength of cast iron by applying rotating bending stresses to the test-bars.* By this testing method only the surface fibres of the bars are subjected to the full force, and, therefore, for the practical application of the experimental results, the stresses of the surface fibres must be determined. As for these determinations the elastic properties of the material must be known, the elasticity of some cast irons was first examined.

From the fact that the bad mechanical properties of cast iron must be attributed, for the most part, to the presence of the graphite flakes, the authors concluded that steel bars, when provided with slots which interrupt the cohesion of the metallic ground mass, must show the elastic properties of cast iron. Therefore, elongation measurements were made with flat steel bars into which slots 0.0118 in. wide and from 0.0394

FIG. 1.

to 0.118 in. long had been cut. It was found that the modulus of elasticity decreases with the increasing length of the slots being 632,000 tons per sq. in. with the sample containing the longest slots. The gradual diminution of the modulus must be explained by the occurrence of additional stresses along the edges of the slots, which increase with the increasing length of the

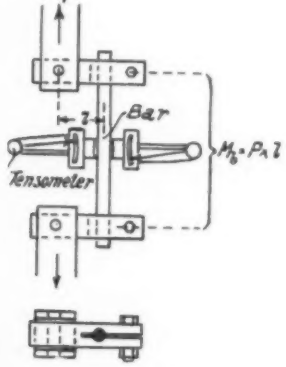


FIG. 2.

slots. Besides this, the areas around the slots are subjected to bending stresses which also increase with the increasing length of the slots.

Further elongation measurements were made with some cast irons, and it was found that the modulus of elasticity is influenced by the number and form of the graphite flakes. The compositions of the irons investigated are set out in Table I, together with the static strengths and the moduli of elasticity. Though the irons Nos. 1 and 3 contain higher percentages of graphite than Nos. 2 and 4, they show higher moduli of elasticity, because the graphite is present in the form of short lamellæ or nodules. From the test data it can also be seen that with high-strength irons the difference between the modulus in compression and that in tension is smaller than with irons rich in graphite.

TABLE I.

Sample No.	Chemical composition.							Static strengths.				Moduli of elasticity. Tons per sq. in.			
	T.C.	C.C.	Gr.	Si	Mn	S	P	Tensile strength. Tons per sq. in.	Transverse strength. Tons per sq. in.	Deflection in.	Brinell No.	In tension. Stress 0 to 1.27 tons per sq. in.	In tension. Stress 5.08 to 6.35 tons per sq. in.	In compression. Stress 0 to 1.27 tons per sq. in.	In compression. Stress 5.08 to 6.35 tons per sq. in.
1	3.22	1.37	1.85	1.15	0.91	0.12	0.39	17.8	30.12	0.386	241	876,000	857,000	920,000	857,000
2	2.94	1.39	1.55	2.0	1.07	0.06	0.22	18.4	26.0	0.345	266	794,000	781,000	920,000	818,000
3	3.35	0.85	2.50	1.46	0.97	0.078	0.40	18.4	34.02	0.413	220	736,000	673,000	889,000	851,000
4	3.30	0.86	2.44	1.8	0.9	0.08	0.5	15.9	34.02	0.508	227	727,000	568,000	734,000	726,000
5	3.77	0.85	2.92	1.85	0.63	0.12	0.68	11.87	24.61	0.551	190	568,000	422,000	564,000	565,000
6	3.3	0.7	2.6	2.6	0.8	0.1	0.5	9.96	24.01	0.516	187	482,000	342,000	486,000	635,000

TABLE II.

Sample No.*	5				3			
Theoretical stress. Tons per sq. in.	Actual stress. Tons per sq. in. Cross section No.				Cross section No.			
	1	2	3	4	1	2	3	4
1.27	1.27	1.27	1.33	1.24	1.27	1.24	1.27	1.27
2.54	2.54	2.41	2.54	2.29	2.48	2.48	2.48	2.54
3.81	3.62	3.43	3.46	3.37	3.75	3.62	3.56	3.75
5.08	4.63	4.45	4.45	4.19	4.82	4.70	4.76	4.76
6.35	5.46	5.33	5.21	5.08	5.91	5.71	5.84	5.71
7.62	6.41	6.22	5.97	5.84	6.98	6.79	6.79	6.60
8.89	—	—	—	—	7.92	7.81	7.81	7.62
10.16	—	—	—	—	9.01	8.76	8.76	8.44
Tensile strength. Tons per sq. in.	12.18	12.38	11.82	12.83	18.74	18.28	18.92	18.42
Transverse strength Tons per sq. in.	19.95	22.45	23.55	30.75	30.15	31.55	35.25	40.65
Tensile strength / Transverse strength	1.64	1.81	2.0	2.4	1.61	1.72	1.86	2.21

* Chemical composition, see Table I.

In further experiments the authors determined the actual stresses to which the surface fibres of bars of different cross sections are subjected when statically bent. The cross sections examined are shown in Fig. 1. The bars were bent in a tensile-test machine in the manner indicated in Fig. 2; in this way the bending moment was the same over the whole length of the bars. The stresses belonging to the total elongations revealed by the bending test were read from the stress-elongation diagrams determined with a tensile test and a compression test-bar cut from the bending test-bar. These stresses are recorded in Table II together with the theoretical stresses calculated according to the formula:

$$\text{stress} = \frac{\text{bending moment}}{\text{moment of resistance}}.$$

The determinations were arithmetically checked and were found to be correct in the range of ± 2 per cent. From the table it can be seen that the differences between the actual and the theoretical stresses increase with the increasing bending moment. These differences are greater with iron No. 5, which is richer in graphite than iron No. 3. Furthermore, the influence of the cross section becomes apparent at about 3.2 tons per sq. in. with iron No. 5; but at 7.6 tons per sq. in. with iron No. 3. The greatest difference is found with cross section No. 4, where the material accumulates around the neutral axis.

By theoretical considerations the authors show how the stresses are distributed in a bar which is subjected to rotating bending, and that in this case the difference between the actual and the theoretical stresses must be smaller than with a bar which is statically bent. These considerations were checked by experiments with round bars which were tested in a Schenck machine. The results are recorded in Table III.

The authors then examined the damping effect of some cast irons (that is, the capability of converting by friction part of the energy applied to them into heat) by determining the hysteresis

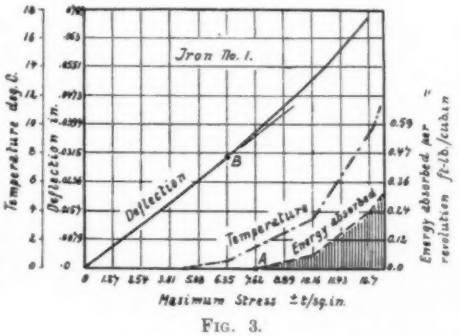


FIG. 3.

curves under various static loads. It was found that the area of the curve, that is, the damping effect, at a given load is greater with an iron rich in graphite than with a high-test iron. The same result was obtained by measuring the energy absorbed by the test-bar when subjected to rotating bending stresses in the Schenck machine. The increase in temperature of the bar was determined with a thermo-couple attached to the middle of the bar. The results of two experiments are illustrated in Figs. 3 and 4. Iron No. 1, the fatigue strength of

* "Die Giesserei," 1929, Nos. 22 and 24.

which was determined later on to be ± 6.98 tons per sq. in., shows no absorption of energy that is no damping effect at the fatigue limit; whereas the damping effect of iron No. 6 begins at very low loads (point A). The damping effect that in cast iron as well as in many other materials, the fatigue is localised, that is, the fracture begins in a distinct area which is especially weakened by an unfavourable form of the graphite flakes or other causes.

TABLE III.

Sample No.*	5		3	
Theoretical stress. Tons per sq. in.	Actual tension stress. Tons per sq. in.	Actual compression stress. Tons per sq. in.	Actual tension stress. Tons per sq. in.	Actual compression stress. Tons per sq. in.
± 1.27	+ 1.24	− 1.27	+ 1.27	− 1.27
± 2.54	+ 2.32	− 2.48	+ 2.54	− 2.54
± 3.81	+ 3.46	− 3.68	+ 3.81	− 3.81
± 5.08	+ 4.61	− 4.89	+ 4.95	− 4.98
± 6.35	+ 5.71	− 6.00	+ 6.06	− 6.18
± 7.62	+ 6.57	− 6.88	+ 6.98	− 7.36
± 8.89	—	—	+ 8.00	− 8.57
±10.16	—	—	+ 8.88	− 9.42

* Chemical composition, see Table I.

seems to be influenced by the graphite content in the same sense as the modulus of elasticity is influenced. From the data it can also be seen that the temperature of the bar increases before an absorption of energy by the bar is indicated by the machine; but the temperature measurement, though more sensitive, is only qualitative.

The authors then examined the fatigue strength of different cast irons by subjecting them to rotating bending stresses in the Schenck testing machine. The determinations were made with three bars of each composition according to the following method. It was found that a relationship exists between the absolute deflections of the rotating bars and the fatigue strength, inasmuch as for a given load the deflections are greater with the lower fatigue strength. This relationship is illustrated in Fig. 5; from this diagram the approximate value of the fatigue strength can be read. With the first bar the deflection curve was determined by increasing the bending moment every two minutes until the stress was about 1.9 tons per sq. in. below the approximate value of the fatigue strength; then the bending moment was increased every fifteen minutes that the bend in the curve which takes place when the fatigue limit is reached could clearly be seen. With the two other bars long period tests were made. The results are recorded in Table IV. From column 7 it can be seen that the bend in the deflection curve gives the fatigue strength with a deviation of ± 0.64 tons per sq. in. Column 6 shows that the fatigue strength cannot be determined by examining the beginning of the damping effect as is the case with steel, because with cast iron these two values approximately coincide only with high-test iron, as stated above (see Figs. 3 and 4). A distinct relationship between the fatigue strength and the tensile strength could not be established (see column 5). The highest fatigue strengths were found with irons showing a pearlitic matrix and a fine distribution of the graphite; whereas the lowest strengths were associated with a ferritic matrix.

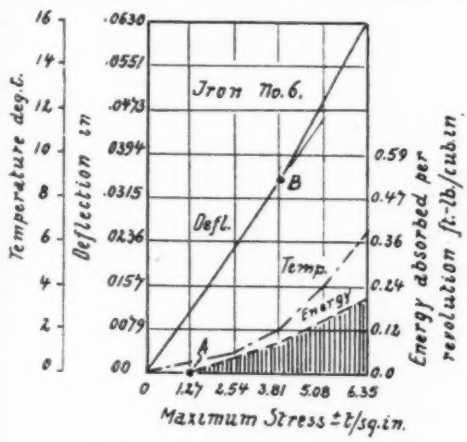


FIG. 4.

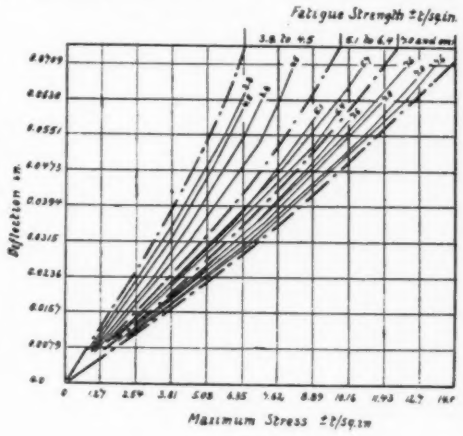


FIG. 5.

That the damping effect depends from the graphite content was also shown by a bar cut from the centre of a casting and which showed a higher damping effect than bars cut from the outer zones of the same casting. By the micrographic inspection of broken bars it was stated that the fracture is caused by fine cracks extending from the ends of the graphite flakes just below the surface of the bar. From the deflection-revolution curves at various loads and the transverse strength the authors conclude

The N.I.E.F. President.

MR. JAMES SMITH.

Mr. James Smith, the recently elected chairman of the National Ironfoundry Employers' Federation, is also President of the North of England Ironfounder's Association, an office he has held for the past 12 years, and is a past President of the Newcastle section of the Institute of British Foundrymen.

TABLE IV.

1	2							3					4	5	6	7
Sample No.	Chemical composition.							Transverse strength. Tons per sq. in.	Static Deflection. In.	Tensile. Tons per sq. in.	Compression. Tons per sq. in.	Brinell Number.	Fatigue strength. Tons per sq. in.	Fatigue str. / Tensile str.	Beginning of Damping effect. Tons per sq. in.	Bend in the deflection curve. Tons per sq. in.
	T.C.	C.C.	Gr.	Si	Mn	S	P									
2.0	2.94	1.37	1.55	2.0	1.07	0.06	0.22	26.05	0.345	18.4	76.2	266	±7.62	0.41	6.98	6.98
0.01	3.25	0.94	2.31	1.27	1.18	0.08	0.40	31.75	0.472	17.1	63.2	233	±7.62	0.45	6.98	6.35 to 8.25*
0.12	2.94	0.84	2.10	0.91	0.69	0.064	0.21	30.5	0.394	18.4	72.5	204	±7.62	0.42	6.98	6.98
0.15	3.35	1.15	2.20	1.41	0.87	0.10	0.49	29.85	0.354	19.7	—	—	±7.62	0.39	6.98	6.98
3.0	3.35	0.85	2.5	1.46	0.97	0.078	0.40	34.05	0.413	18.4	80.6	220	±7.30	0.40	5.08	6.98
16.0	3.25	0.65	2.55	1.55	0.99	0.064	0.35	31.2	0.445	17.1	49.8	199	±6.98	0.40	3.81	6.98
1.0	3.22	1.37	1.85	1.15	0.91	0.12	0.39	30.15	0.386	17.8	63.5	241	±6.98	0.39	3.81 to 7.62*	6.35
14.1	3.15	1.19	1.96	1.15	0.90	0.08	0.20	28.4	0.488	16.9	64.1	252	±6.98	0.40	6.98	6.98
2.1	3.13	1.18	1.95	1.08	0.77	0.082	0.40	32.3	0.394	16.5	68.6	239	±5.72	0.35	3.81	5.72
4.0	3.3	0.96	2.44	1.80	0.90	0.08	0.50	34.0	0.507	15.9	57.6	227	±5.72	0.36	4.45	5.08
7.0	3.2	0.82	2.38	0.98	0.64	0.085	0.40	—	—	12.5	52.7	215	±5.08	0.36	5.08	5.08
5.0	3.77	0.85	2.92	1.85	0.63	0.12	0.68	24.65	0.551	11.9	63.0	190	±4.45	0.40	1.27	3.81
6.0	3.3	0.70	2.60	2.60	0.80	0.10	0.50	24.0	0.516	9.9	40.7	187	±3.81	0.38	1.27	3.81
3.1	3.3	0.69	2.61	2.33	0.50	0.09	1.39	21.15	0.728	8.9	—	178	±3.81	0.43	1.27	3.18

* Several experiments.

Progress in Metallurgical Research.

By Sir H. C. H. Carpenter, F.R.S. (Prof. of Metallurgy, Imperial College of Science and Technology, South Kensington).

Considered from the standpoint of the progress of research and development, the most important event of the year 1929 is the formation of an Iron and Steel Industrial Research Council composed of members of the Iron and Steel Institute, the National Federation of Iron and Steel Manufacturers, and of Research Associations of industries connected with iron and steel. This Council will fulfil in the iron and steel industry the same functions as are at present fulfilled by the research associations of the non-ferrous and other industries. It will operate under the same conditions as these with respect to state aid, that is, on a pound for pound basis above a certain datum line, and there is every reason to anticipate that its activities will be equally effective in promoting the development of the industry. The policy of the Research Council is evidently, in the first place, the encouragement of definitely technical investigations designed to overcome immediate and pressing difficulties, and to explore the most obvious lines of development by suitable means. But there is no doubt that the various investigations undertaken with these specific objects will gradually extend along more fundamental lines as so many investigations of a similar character have already done.

Production of Sound Steel.

The presentation at the Spring Meeting of the Iron and Steel Institute of the Paper by the Hon. Sir Charles Parsons and Mr. H. M. Duncan on "A New Method for the Production of Sound Steel" was a notable event in the annals of steel metallurgy. This Paper provoked one of the longest discussions that has ever occurred at those meetings; the discussion was extensive, informed and critical, but it was not controversial. Interest in the problems associated with the solidification of large steel ingots has been aroused during recent years by the work of the Heterogeneity Committee, and the appearance of this Paper gave this interest a new impetus. Many of those, who, through association with the work of the Heterogeneity Committee, had come to study the problems of solidification, and many others who are interested in ingots from a manufacturers' or users' point of view, contributed their views to the discussion.

Parsons and Duncan base their method of overcoming segregation and axial unsoundness on the principle that the freezing of the ingot should proceed from the bottom upwards. They accomplished this object by using a mould having its longitudinal dimensions greater than its vertical, by covering the sides of the mould with thick refractory material, by using a very large bottom chill, by preheating the mould, and by continuously applying heat to the upper surface of the metal after casting. Most of these devices have been used before, either singly or in various combinations, but never before has the same combination been used, nor has the same success been attained.

As Mr. T. M. Service pointed out in the discussion, three of the four principal defects associated with steel ingots are overcome by Parsons' and Duncan's method of casting, viz., axial weakness, axial segregation, and inverted cone segregation. The fourth defect, non-metallic inclusions, does not appear to be substantially affected by this new method of casting, for although it might be deduced from theoretical considerations that these inclusions would have an improved opportunity to rise to the surface during the extremely slow cooling of the ingot, they did not do so in practice.

Like the majority of developments in metallurgy, the advantages obtained by this new method of casting are to some extent offset by certain disadvantages. Chief among these is the very coarse crystallisation that must occur during such slow cooling, for there is no doubt that this will be accompanied by a degree of segregation within each crystal that will be difficult to remove by any subsequent treatment. Another disadvantage of the Parsons' ingot is its shape, which would make it very difficult to handle in ordinary rolling mills; and a third disadvantage is the cost of its production. For certain purposes none of these disadvantages will effectively counterbalance the attainment of soundness and freedom from axial segregation, but for general steel-making practice they will present, what must at present be regarded as, insuperable difficulties.

Interest in the Parsons' ingot rather detracted from attention devoted to the important third report of the Heterogeneity Committee, which however was a publication of considerable merit, dealing as it did with some of the fundamental phenomena that underlie the process of solidification. In this connection it is necessary to mention the valuable Paper by Mr. Axel Hultgren, presented at the Autumn Meeting of the Iron and Steel Institute, for in this Paper some new and interesting aspects of crystallisation and segregation phenomena are described.

Blast-Furnace Plant and Practice.

Another event of some importance—also at the Spring Meeting of the Iron and Steel Institute—was the presentation of the "First Report on Blast-Furnace Plant and Practice" by a Committee of the Institute. This Report deals with developments in blast-furnace work during recent years. Although it is not an account of an investigation, nor a presentation of information to which the Committee alone had access, it is nevertheless valuable because of the able way in which the available material has been summarised, and because of the authoritative nature of the comments. Nothing is of more importance at the present time than a full appreciation by British iron-masters of the developments taking place throughout the world. This first report brings to them a concise account of these developments, and much may be anticipated from the further work of this Committee—particularly if the proposal to send qualified investigators to iron-producing districts at home and abroad is carried into effect.

The Erosion of Guns.

It is difficult to get away from the Spring Meeting of the Iron and Steel Institute—for the Papers presented at that meeting were as valuable a collection as has appeared anywhere in recent years—and besides those already commented on, the Paper on "The Erosion of Guns," by Dr. R. H. Greaves, Mr. H. H. Abram and Mr. S. H. Rees must be mentioned. It contains an account of what is probably the most comprehensive investigation of erosion that has ever been carried out, and convincing evidence is furnished in support of the view that erosion is due to the melting and washing away of a thin surface layer at each round. Certain other defects, such as the production of a hard martensitic skin and a network of surface cracks, are also associated with firing, but the rapid deterioration of gun tubes is primarily due to melting. This being so, it is evident that the melting point of the metal of the gun tube, and the calorific value of the propellant, are the critical factors in determining the life of the tube. The authors were able conclusively to demonstrate this fact by means of experiments in erosion vents.

Research in the United States: Nitriding of Steel.

It is noticeable that American investigations are on the whole directed towards ends different from those aimed at in this country. This is true generally, for in each country interest seems to centre on different aspects of metallurgy. There are many reasons for this—certain of them associated with the nature and organisation of the industry of the country and so on; but the principal reason is without doubt the interest that is aroused in a subject by an effective investigation in that subject. Thus in America great interest has been shown in the question of normal and abnormal steels, first raised by Ehn, and in the process of nitriding and the properties of nitride cases. During the last year, two Papers on normal and abnormal steels have been published in the Transactions of the American Society for Steel Treating, which society, besides publishing a number of Papers, also convened a symposium on nitriding. At this symposium nine Papers were presented on various aspects of nitriding. Considerations of space make it impossible to review them here. It must suffice to say that the industrial application of nitriding is almost certain to develop to an increasing extent in the near future.

High-Tensile Structural Steels.

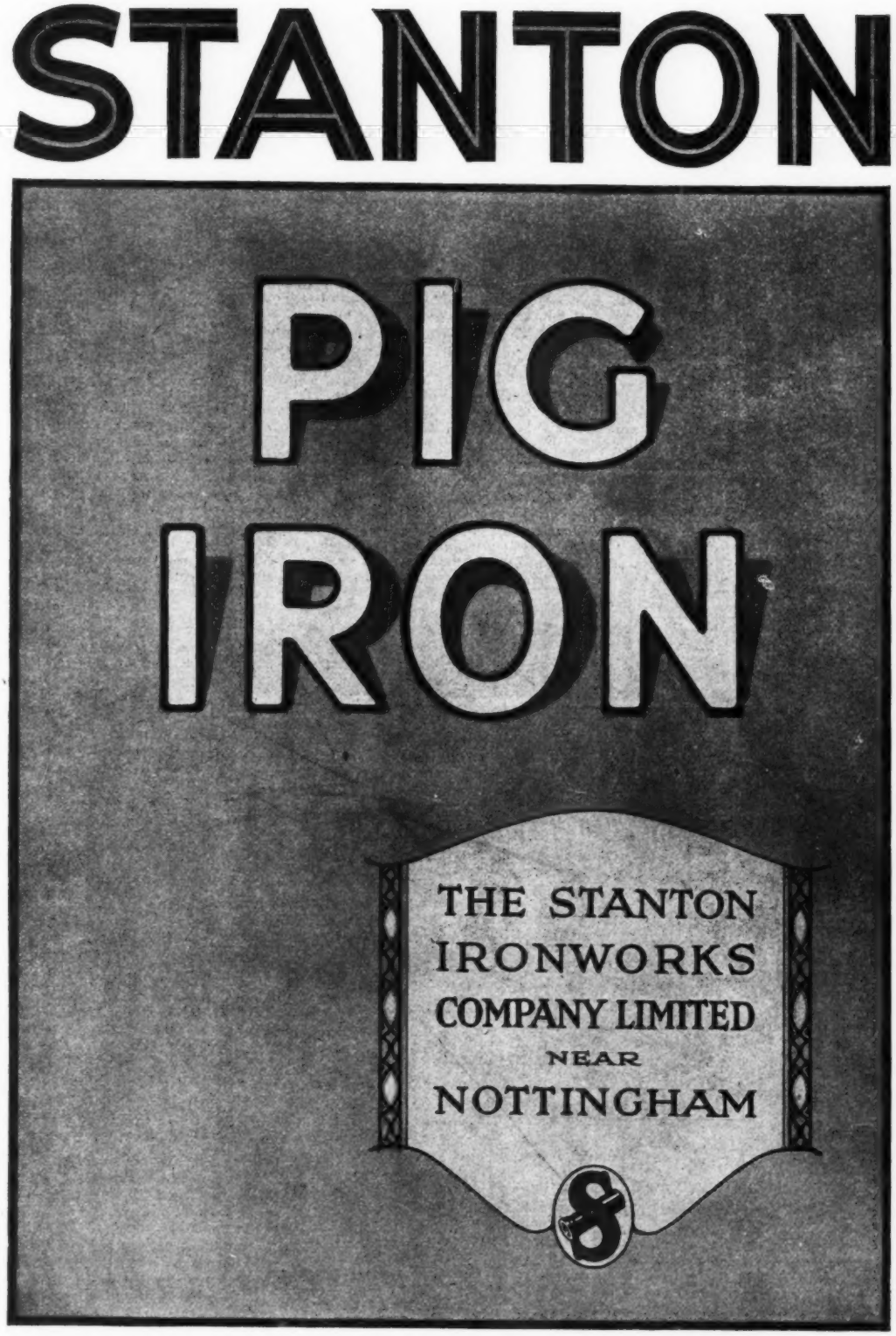
During the year the interest in high-tensile structural steels has been maintained and has even increased. Besides the older forms of high-tensile structural steel which attained their object by raising the carbon or by paying more attention to the physical condition of the finished steel, steels which owe their properties to the presence of more than the ordinary amount of special elements—usually manganese and silicon—have found increasing applications. It appears, however, that there are certain manufacturing difficulties in the large-scale production of high-silicon steels. Moreover, they do not weld readily, and are said to be more susceptible to corrosion than plain carbon steels. In view of this, considerable attention has been attracted by further developments in the use of copper steels, and it is now asserted that steels containing about 1 per cent. of this element combine the necessary mechanical properties with the ability to weld easily, and with a greater than average resistance to corrosion.

Other Researches.

Mention must also be made of the investigations that have been performed on the new cutting-tool material, tungsten carbide, on the superheating of molten cast iron, on the properties of steel at high temperature, and on the now well-known and important phenomenon called corrosion-fatigue. For information on this last subject we are chiefly indebted to Dr. McAdam, of the Experimental Station of the United States Navy, whose work has been published in a series of six Papers during the last three years.

The investigations and developments mentioned above represent only a very small proportion of the total. They have been selected for mention as representative of different types of metallurgical research, all equally important and equally useful. It is gratifying to see that every year brings an increase in the output of research, but it is not so gratifying to reflect that the absorption of the rapidly-accumulating mass of material is increasingly difficult, particularly by those through whose agency the practical utilisation of the information must be effected.

MACHINERY BELTING.—The Standing Committee (General Merchandise) appointed by the Board of Trade have reported on their inquiry as to whether imported machinery belting (including conveyor and elevator bands) other than belting of metal should be required to bear an indication of origin. The report is obtainable from the Stationery Office, or through any bookseller, price 2d.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Trade Talk.

THE LYONS FAIR is this year to be held from March 3 to 16, and agricultural implements are to be the feature.

H.M. REPRESENTATIVE AT Buenos Aires reports a Decree which prohibits the export from Argentina of iron and scrap iron.

THE DIRECTORS of the Vereinigte Stahlwerke A.G. have decided to propose at the general meeting next month a dividend of 6 per cent., the same as last year.

MESSRS. FERGUSON BROS., Port Glasgow, have launched the twin-screw passenger tender "Romsey," built for the Alexandra Towing Company, Limited, Liverpool.

MESSRS. ROBERT STEPHENSON & COMPANY, LIMITED, Darlington, have received an order for 20 tank locomotives of the 0-6-2 type for the Central Argentine Railways.

THE ARMOUR-PLATE MILLS at the works of Messrs. John Brown & Company, Limited, Sheffield, have been restarted, and will be busy for about six weeks rolling plates for warships.

AT A MEETING of the German Steel Trust, held on January 23, it was announced that the net profits of the concern for the past business year amounted to 52,669,000 mks.—about £2,634,950.

THE LIGHT-CASTINGS INDUSTRY in the Bonnybridge and Falkirk districts since the resumption after the holidays has been so slack that the working week has been reduced to four days in a number of the foundries.

H.M. TORPEDO-BOAT DESTROYER "Anthony," built by Messrs. Scotts, Greenock, has just completed its trials with marked success, and has attained a speed of 37¼ knots, a record for a British cruiser or destroyer.

AT THE Consett (Durham) Iron Company's works, on January 22, two men, William Arthur Young, of Castleside, Consett, and Patrick McCourt, of Consett, were so badly burned that they died a few hours later. They had been engaged in tapping a large blast furnace, which exploded and covered them with molten metal.

MESSRS. DORMAN, LONG & COMPANY, LIMITED, have decided to close down next month the only remaining active furnace of their group of three at the Carlton Ironworks, County Durham. The furnace is producing ferro-manganese, which in future will be manufactured at the South Bank works of the new Dorman-Bolckow combine.

ORDERS FOR three new oil-carrying vessels have been placed with Clyde firms by the Anglo-Persian Oil Company, Limited. Two will be built by Messrs. Lithgows, Limited, Port Glasgow, and the third by the Greenock Dockyard Company, Limited, Greenock. All three vessels are to be fitted with Burmeister & Wain engines constructed by Messrs. John G. Kincaid & Company, Limited, Greenock.

AN ARRANGEMENT has been made between Messrs. W. Beardmore & Company, Limited, and David Colville & Sons, Limited, whereby the latter will acquire the goodwill of Messrs. Beardmore's business in so far as it relates to plates, sections and rails. The complete arrangement will operate as from February 1 next, and no amalgamation, interchange of shares or any form of merging, financial or otherwise, is involved.

THE EMPLOYEES of the following firms have contributed to infirmaries and other charitable institutions in Glasgow and the West of Scotland:—John Browne & Company, Limited, Clydebank, £2,377; Lanarkshire Steel Company, Limited, Motherwell, £675; Cruickshank & Company, Limited, Denny, £150; Cameron & Roberton, Limited, Kirkintilloch, £89; Babcock & Wilcox, Limited, Dumbarton Works, £201

TWO NEW LINERS have been ordered from Messrs. Vickers-Armstrongs, Limited, Barrow-in-Furness, by the Peninsula & Oriental Steam Navigation Company. They will be propelled by turbo-electric machinery, manufactured by the British Thomson-Houston Company, Limited, of Rugby, acting in collaboration with Vickers-Armstrongs, Limited. The boilers will be of the latest high-pressure type, designed by Messrs. Yarrow & Company, Limited, Scotstoun.

MESSRS. KERR, MACLEOD & MACFARLANE C.A., Glasgow, have intimated to Messrs. James C. Bishop & Owen Coyle, joint secretaries of the Board of Conciliation for the Regulation of Wages in the Pig-Iron Trade of Scotland, that, on an examination of the employers' books for the last three months of 1929, they certify the average net selling price to be £3 17s. 3d. This means there will be an increase in the workmen's wages of 2 per cent. on basis rates.

THE STANTON IRONWORKS COMPANY, LIMITED, near Nottingham, have acquired the sole British rights of the Victaulic joint for use with cast-iron pipes. The Victaulic joint is already known for gving flexibility to a pipe line at each of the joints, and it is anticipated that in the hands of the Stanton Company this joint will be extensively adopted for cast-iron pipes, thereby introducing flexibility into cast-iron mains. In connection with the Stanton Company's well-known spun pipe, a special form of Victaulic joint has been designed which obviates the use of the housing.

WITH REGARD to reports which have been circulating concerning the future of Messrs. Thos. Firth & Sons, Limited, and Messrs. John Brown & Company, Limited, and their probable absorption in the English Steel Corporation, Limited, it is now stated that there is unlikely to be any such merger for some considerable time to come. A year ago negotiations were opened to explore the ground, but the parties have had no meeting since last August, and it is improbable that they will meet again in the near future. The two firms, Thos. Firth and Sons and John Brown & Company, are, however, at present engaged in certain negotiations for a more complete merger of their own interests. At present the two concerns are connected by the fact that Messrs. John Brown & Company have a large holding of the share capital of Messrs. Thos. Firth & Sons, and it is hoped that a fusion of interests may be brought about that will enable them to apply the benefits of rationalisation to their works.

NEW GOVERNMENT CONTRACTS listed in the "Ministry of Labour Gazette" include the following:—Admiralty: Steelwork, Dorman, Long & Company, Limited, Middlesbrough; phosphor bronze, C. Clifford & Son, Limited, Birmingham; zinc sheets, London Zinc Mills, Limited, London. War Office: Locomotive, English Electric Company, Limited, Preston; nickel-chrome steel, Hadfields, Limited, Sheffield; steel castings, English Steel Corporation, Limited, Sheffield; mild-steel plates, Wm. Beardmore & Company, Limited, Glasgow; steel bars, etc., Steel, Peech & Tozer, Limited, Sheffield; zinc, British Metal Corporation, Limited, London, and H. Gardner & Company, Limited, London. Crown Agents for the Colonies: Boilers, Stothert & Pitt, Limited, Bath; bolts and nuts, Chas. Richards & Sons, Limited, Darlaston; pipes, British Mannesmann Tube Company, London, and Stewarts & Lloyds, Limited, Glasgow; steel, P. & W. Maclellan, Limited, Glasgow; steel plates, F. Braby & Company, Limited, London; steel sheets, Wolverhampton Corrugated Iron Company, Limited, Wirral; steel sleepers, Dorman Long & Company, Limited, and United Steel Companies, Limited, Workington; steel-sleeper keys, Guest, Keen & Nettlefolds, Darlaston; steel tanks, Brown, Lenox & Company (London), Limited, London; steelwork, Braithwaite & Company, Limited, London; Brownlie & Murray, Limited, Glasgow; Head, Wrightson & Company, Limited, Thornaby-on-Tees; and Tees-side Bridge & Engineering Works, Middlesbrough.

Contracts Open.

Bridgwater, February 3.—Cast-iron goods, lead pipe, etc., for the Corporation. Mr. R. A. Watson, borough engineer and surveyor.

Coalville, Leics, February 4.—340 tons of 12-in., 9-in. and 8-in. cast-iron pipes and specials, etc., for the Urban District Council. Messrs. Pick, Everard, Keay & Gimson, 6, Millstone Lane, Leicester. (Fee £1 1s., returnable.)

Johannesburg, February 8.—11,500 ft. of Siemens-Martin open-hearth steel piping, for the City of Johannesburg. The Department of Overseas Trade. (Reference A.X. 9,046.)

London, N., February 5.—Solid-drawn steel tube street lamp columns, 21 ft. 6 in. in length, with cast-iron bases, etc., for the Islington Electricity and Lighting Committee. The Borough Electrical Engineer, 60, Eden Grove, Holloway, London, N.7.

Manchester, February 3.—Ventilating grids and other castings, for the Corporation. Mr. J. Irvine, manager of the drainage branch, Public Health Department, Phœnix Buildings, 20, Cooper Street, Manchester.

Personal.

MR. A. N. DAVIDSON, sales manager of Imperial Chemical Industries, Limited, at Gateshead, has been transferred to the firm's head offices in London.

MR. A. BLACKMORE has relinquished his position as secretary and routine director of the United Steel Companies, Limited, United Strip & Bar Mills, Limited, and United Coke & Chemicals Company, Limited.

MR. MAURICE S. GIBB, managing director of the Central Marine Engine Works, West Hartlepool, of Messrs. William Gray & Company, Limited, has been re-elected President of the North-East Coast Engineering Employers' Association.

MR. J. A. THORNTON, works manager of the Britannia Works of Messrs. Dorman, Long & Company, Limited, Middlesbrough, has been the recipient of a presentation on leaving the firm to take up a position with the Partington Steel & Iron Company, Limited, Irlam.

MR. T. L. POOLE, for the past 15½ years blast-furnace manager for the Low Moor Company, Limited, Messrs. Robert Heath & Low Moor, Limited, and latterly the Low Moor Iron Company, Limited, at Low Moor, has severed his connection with the latter firm.

MR. H. B. WORDSWORTH, works manager of Industrial Combustion Engineers, Limited, was the recipient of a presentation from the directors and staff of the company at a gathering in Derby. Mr. Wordsworth, who has just completed 18 years' service with the company and its allied concerns, is leaving to take up an appointment in the North.

MR. GEORGE REID, who retired from the managing directorship of Messrs. Drysdale & Company, Limited, Bon Accord Works, Yoker, on December 31, 1929, was entertained to dinner in Glasgow on January 18. The directors and his colleagues of the staff presented him with a gift to mark his retirement after more than fifty years' service with the firm, twenty-two of which he has acted as a director.

Wills.

SMITH, W. B., Glasgow, sole partner of the Clydesdale Steel & Foundry Company	£42,831
GIBBONS, H., of Messrs. Gibbons, Skinner & Company, iron and steel merchants, 30, Wharf Road, London, N.1 ...	£22,543
SMITH, GEORGE (otherwise George Scoby), Middlesbrough, for 60 years in the service of Messrs. Bolckow, Vaughan & Company, Limited, a director and commercial manager of the company	£23,886

Obituary.

MR. WILLIAM ATKINS, of Messrs. Atkins Metals, Limited, metal merchants and refiners, Bradford Street, Birmingham, died recently. Mr. Atkins had been engaged in Birmingham as a metal merchant for about forty years.

WE REGRET to announce the sudden death of Mr. C. F. Walker, foundry foreman at the Wolverton establishment of the London Midland & Scottish Railway Company. Mr. Walker was a prominent member of the London Section of the Institute of British Foundrymen.

MR. EDWARD N. MACKLEY, of Messrs. E. N. Mackley & Company, engineers and ironfounders, of Gateshead, has died at the age of 54. He was a member of the Institution of Mechanical Engineers, the North-East Coast Institution of Engineers and Shipbuilders, the Institute of Mining and Electrical Engineers and a Fellow of the Royal Society and the British Association for the Advancement of Science.

ONE OF THE best-known and most highly-esteemed ironfounders on the North-East Coast has been removed by the death, which occurred on Friday last, of Mr. James Duncan Carmichael, managing director of Messrs. Carmichael Bros., Limited, ironfounders, of Nile Street, South Shields. A native of Glasgow, the deceased settled on Tyneside fifty years ago, and served with his father in the foundry, which was converted into a limited liability company in 1910. He was a president of the Newcastle Section of the Institute of British Foundrymen in 1918-1919, a member of the Marine Engineers' Institute, and a prominent Freemason. A widow, daughter and two sons survive him.

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TO BRITISH STEELFOUNDERS

THE SAFEGUARDING OF BRITISH STEEL FOUNDRY SAND against the competition of Foreign Sands produced under conditions entirely different from those at home, and free from the burdens and charges British Industry is carrying, is long overdue.

A QUESTION

Do British Steelfounders realise that every pound spent in British Sands tends to come back to them because it is spent in this country, but that every pound spent in Foreign Sands is not only lost to them but by affecting the rate of exchange against this country, tends to make food imports more costly?

A CHALLENGE

Our new Sand Milling and Mixing plants being now completed, we having equipped ourselves with Mechanical Excavators, Disintegrators, Loaders and such plant as will compare with any in the world; owning our own land, quarries and railway trucks, in a word, having equipped ourselves to the best of our knowledge and ability and in a manner we feel to be worthy of the reputation of

"YORKSHIRE SAND"

now offer to meet any foreign competition.

We offer to supply British Steel Foundry Sand

AS CHEAP AS ANY FOREIGN SAND OR CHEAPER
AS GOOD AS ANY FOREIGN SAND OR BETTER

AND we will give you instant delivery from one of four points.

☞ **In truck loads** (not asking for orders for 200 or 300 tons)

☞ **On Monthly Account**
(Not asking for cash against Bill of Lading)

WE KNOW YOU REALLY PREFER TO USE BRITISH SAND AND WE HERE AND NOW INVITE YOU TO ACCEPT OUR OFFER AND TO COMMUNICATE WITH US.

Iron and Steel Markets.

Pig-Iron.

MIDDLESBROUGH.—Reviewing the course of business during the opening month of the year, it must be admitted that the results, as far as concerns the Cleveland iron market, have been disappointing and very much contrary to general expectations of an early improvement in trade conditions. The leading market for pig-iron, to put it bluntly, no longer holds the supremacy it formerly enjoyed in the great national industry, attendances at the weekly meetings having dwindled in numbers and general interest being confined to hand-to-mouth transactions almost routine in character. There can, however, be little doubt that the policy of the Cleveland ironmasters is largely governed at the moment by the instability in the political position, accentuated by uncertainties in regard to the effect of the Coal Mines Bill, uncertainties respecting the fate of the McKenna duties, and apprehensions regarding the possibility of oppressive taxation in the next Budget, all tending to undermine that confidence which is the basis of business enterprise. Consequently few sales on forward account are reported, while export business, though slightly improved, is not important in volume. Prices meanwhile remain at the fixed minima, namely, No. 1 Cleveland foundry iron 75s., No. 3 G.M.B. 72s. 6d., No. 4 foundry iron 71s. 6d., and No. 4 forge iron 71s. per ton.

Although it is true that the East Coast hematite makers have some big contracts on their books for deliveries extending to the end of March, there has been a noticeable slackening in the demand during the last week or two. Prices also show signs of an easier tendency of late, and prompt parcels of mixed numbers are obtainable at as low as 78s. per ton, with No. 1 offered at 78s. 6d., although possibly 6d. more is quoted by some of the producing firms. On the North-West Coast, Bessemer mixed numbers are quoted at 78s. per ton at works.

LANCASHIRE.—Industrial conditions as regards pig-iron consumption in this area continue fairly satisfactory, a moderate increase of demand on the part of the local foundries being reported, and deliveries on a good scale are going forward week by week. In the meantime, there is no change in values to report, Midland makes—Derbyshire and Staffordshire—both being quoted at 77s. per ton, with Scottish brands firm at around 95s. per ton, all delivered locally.

THE MIDLANDS.—Ironfounders in this area, although fairly well employed, are not at the moment disposed to entertain much forward business in pig-iron, and markets are consequently quieter than has been the case during the past few months. Recent anticipations of a rise in prices have so far not materialised, quotations still ruling at 75s. for Northants No. 3 and 78s. 6d. for Derbyshire and North Staffordshire No. 3, delivered to local stations.

SCOTLAND.—Business in Scotch pig-iron continues on a restricted scale, and many of the foundries are only partially employed. The price of No. 3 Scotch foundry pig-iron remains unaltered at 78s. minimum f.o.t. furnaces, with 2s. 6d. per ton extra for No. 1. The quotations for export are 84s. for No. 1 and 81s. 6d. for No. 3, f.a.s. Glasgow.

Finished Iron.

At Birmingham during the current week the position in regard to bar iron has remained very unsatisfactory in so far as it affects crown bars and the cheaper grades of iron. There has been, however, a little more business moving for Staffordshire marked bars, good-quality chain and cable irons, and the works making this material are situated in a favourable position for the time being. The price of marked bars is £12 10s. at works, but crown bar prices continue to vary and are at anything from £10 to £10 10s. The local price for nut and bolt iron also varies considerably, and the current rates are from £9 2s. 6d. to £9 7s. 6d. There is, however, very little business possible at these rates, only spot lots which are wanted promptly being bought, as the bulk of the trade is going to the Continent.

Steel.

The position in the home markets for steel and semi-products recently has been disturbed by the Cartel negotiations which have been going on amongst Continental steelmakers. The uncertainty as to the outcome of these negotiations has reacted upon most of the export markets, and buying appears to have been held up in consequence. This result has, at all events, been evident at Sheffield, where business has been distinctly on the slow side, with only a poor demand for Siemens acid billets, but basic billets continue active, despite the sharper competition from imported material. The dealings in wire rods are on a smaller scale. Current prices are:—Siemens acid billets, £9 10s.; basic billets, soft, £6 15s.; medium hard, £7 12s. 6d.; medium, £8 2s. 6d.; hard, £9 2s. 6d. to £9 12s. 6d.; basic wire rods, soft, £8; medium hard, £9 15s. to £10; hard, £10 10s. to £11; acid, £12 5s. to £12 10s. In the tinplate market prices continue steady at about previous figures, with a fair volume of business passing.

Scrap.

During the past week the demand for foundry scrap material has been quiet, and can hardly be expected to improve until the year has advanced a little further. On Tees-side this week the foundries continue on the slack side, with little change in prices of ordinary heavy cast iron at 62s. 6d. and good machinery quality in handy sizes at 66s. 6d. per ton. In the Midlands, the prices recently reported for heavy cast-iron scrap have been maintained, and quotations are firm. Heavy machinery cast-iron scrap realises 70s. per ton delivered, and 65s. per ton for ordinary heavy metal and 60s. per ton for light cast iron is offered. In Scotland, the cast-iron scrap market has not improved, and machinery quality is still quiet at around 70s.; ordinary heavy cast iron, suitable for foundries, is 63s. 6d. to 65s., old cast-iron railway chairs are 67s., and for light cast iron 58s. 6d. to 60s. is quoted. The above prices are all per ton delivered f.o.t. consumers' works.

Metals.

Copper.—The decline in consumptive demand continues with steady persistency, with, so far, little effect upon current market values of warrant copper, which now stands at an entirely artificial quotation, due to the retention of the absurdly high price of 18 cents per lb. by the large American producers. Business has consequently almost reached a standstill, and purchases are made for urgent requirements only. Substitutes are coming more into use. The producers, however, are attempting to deal with the situation by decreasing their production, and further cuts in output have been announced.

Closing quotations are :—

Cash.—Thursday, £71 10s. to £71 12s. 6d.; Friday, £71 10s. to £72; Monday, £71 10s. to £71 12s. 6d.; Tuesday, £71 10s. to £71 12s. 6d.; Wednesday, £71 16s. 3d. to £72.

Three Months. — Thursday, £68 10s. to £68 12s. 6d.; Friday, £68 2s. 6d. to £68 10s.; Monday, £68 2s. 6d. to £68 5s.; Tuesday, £68 8s. 9d. to £68 10s.; Wednesday, £68 17s. 6d. to £69.

Tin.—Restriction of output also seems just now to be the keynote of the Tin Producers' Association, and, according to all indications, the plan is meeting with considerable success. It is known that several companies in Malay have suspended production for one day in the week, and Nigerian producers have recommended a curtailment of 20 per cent. of their output, but so far Bolivian producers have remained silent. There is a heavy accumulation of stocks in Liverpool warehouses, and prices, partly on that account, have fallen to still lower levels.

Official closing prices :—

Cash.—Thursday, £172 to £172 2s. 6d.; Friday, £172 10s. to £172 15s.; Monday, £174 10s. to £174 15s.; Tuesday, £176 7s. 6d. to £176 10s.; Wednesday, £180 10s. to £180 12s. 6d.

Three Months.—Thursday, £175 5s. to £175 10s.; Friday, £175 12s. 6d. to £175 15s.; Monday, £177 15s. to £178; Tuesday, £179 10s. to £179 12s. 6d.; Wednesday, £183 15s. to £183 17s. 6d.

Spelter.—In the case of this metal also, in view of the abnormally heavy stocks accumulated, the outlook is not very encouraging. The price is very low, and, without a considerable recovery in the consuming trades, there is every prospect of it remaining so. Belgian producers have not despaired of forming a new European Cartel, and fresh efforts have been made to come to some sort of an agreement.

Daily quotations are :—

Ordinary. — Thursday, £19 15s.; Friday, £19 16s. 3d.; Monday, £19 17s. 6d.; Tuesday, £19 16s. 3d.; Wednesday, £20 1s. 3d.

Lead.—The market for soft foreign pig maintains its position with remarkable steadiness, although the consumptive demand is insufficient to absorb the available supply.

The week's prices have been :—

Soft Foreign (Prompt).—Thursday, £21 12s. 6d.; Friday, £21 12s. 6d.; Monday, £21 12s. 6d.; Tuesday, £21 12s. 6d.; Wednesday, £21 11s. 3d.

A MEETING OF preference shareholders of Messrs. Richard Thomas & Company, Limited, called by the Provisional Committee of preference shareholders, was held in London last week, Mr. George Cursons presiding. It was recalled that at the last general meeting of the company the chairman drew attention to the necessity for raising additional capital to carry out certain extensions. In view of the fact that the preference shares had depreciated so much in value and that no dividend had been paid for over three years, it behoved the preference shareholders carefully to consider the need for close co-operation. Any additional capital raised now must come in front of the existing preference share capital. That being so, the preference shareholders would be well advised to take concerted action now to see that their rights were suitably safeguarded. After some discussion the meeting appointed Messrs. George Cursons, Harold Jeans and W. H. Charles, with power to add to their number, as a committee for the protection of the rights and interests of the preference shareholders.

CAST IRON FLANGED PIPES
2 in.–12 in. & CONNECTIONS. to 24 in. dia.
WE HAVE FIFTY YEARS OF ACCUMULATED EXPERIENCE AND METAL PATTERNS.
JAMES & RONALD RITCHIE, LTD.,
Telephone: 52 & 53. MIDDLESBROUGH. Telegrams: "Ritchie, Middlesbrough."

BEDWAS NAVIGATION FOUNDRY COKE

(Produced from the world-famous Bedwas Coking Coal.)

The British Benzol & Coal Distillation, Ltd., beg to announce that their new Woodall-Duckham Plant at Bedwas is now in operation.

Enquiries are invited from all those interested in high-grade Foundry and Furnace Coke.

S. INSTONE & CO., LTD.,
Sole World Sales Agents,
Baltic House, CARDIFF.

Agents for the Midlands :
J. C. ABBOTT & CO., LTD.,
Lloyds Bank Chambers,
New Street, BIRMINGHAM.

WARNER'S CYLINDER PIG IRON

BRAND "WARNER C.P.R."

THE WORLD'S BEST

As supplied to the leading....
RAILWAY COMPANIES, LOCOMOTIVE, DIESEL and OIL ENGINE BUILDERS.
Also unequalled for
AUTOMOBILE CYLINDER BLOCKS. COMPRESSORS, ENGINEERS' TOUGH CASTINGS and CHILLED ROLLS.

WARNER & CO. LTD.
CARGO FLEET,
MIDDLESBROUGH ON TEES.

TELEGRAMS:
REFINERY MIDDLESBROUGH.

ALSO MAKERS OF
HIGH CLASS REFINED PIG IRON
IN SMALL PIGS, FOR ALL KINDS OF
MALLEABLE CASTINGS

TELEPHONE:
MIDDLESBROUGH 4265.

XUM

WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash	71	16	3
Three months	68	17	6
Electrolytic	83	10	0
Tough	76	0	0
Best selected	76	10	0
Sheets	110	0	0
India	90	10	0
Wire bars	84	2	6
Do. Jan.	84	2	6
Do. Feb.	84	2	6
Ingot bars	84	2	6
H.C. wire rods	86	5	0
Off. av. cash, December	68	7	3¾
Do., 3 mths., December	67	15	10⅞
Do., Sttlmnt., December	68	7	3
Do., Electro, December	83	3	6¾
Do., B.S., December	75	16	4½
Do., wire bars, December	83	15	9
Aver. spot price, copper, Dec.	68	7	3¾
Solid drawn tubes			15d.
Brazed tubes			15d.
Wire			11½d.

BRASS.

Solid drawn tubes	12¾d.
Brazed tubes	14¾d.
Rods, drawn	12½d.
Rods, extd. or rlld.	7½d.
Sheets to 10 w.g.	11½d.
Wire	10½d.
Rolled metal	10½d.
Yellow metal rods	7½d.
Do. 4 × 4 Squares	8d.
Do. 4 × 3 Sheets	8½d.

TIN.

	£	s.	d.
Standard cash	180	10	0
Three months	183	15	0
English	182	0	0
Bars	179	10	0
Straits	178	2	6
Australian	177	7	6
Eastern	180	0	0
Banca	182	7	6
Off. av. cash, December	179	10	2¼
Do., 3 mths, December	182	14	0
Do., Sttlmt., December	179	9	7½
Aver. spot, December	179	10	2¼

SPELTER.

	£	s.	d.
Ordinary	20	1	3
Remelted	18	5	0
Hard	16	10	0
Electro 99.9	22	2	6
English	20	5	0
India	18	0	0
Zinc dust (Nom.)	30	0	0
Zinc ashes	6	0	0
Off. aver., December	20	7	5¼
Aver., spot, December	20	1	3¼

LEAD.

	£	s.	d.
Soft foreign ppt.	21	11	3
English	23	0	0
Off. average, December	21	9	6¾
Average spot, December	21	9	5¼

ZINC SHEETS, &c.

	£	s.	d.
Zinc sheets, English	30	0	0
Do. V.M. ex-whf.	27	15	0
Rods	34	0	0
Boiler plates	26	10	0
Battery plates	27	0	0

ANTIMONY.

	£	s.	d.
Special brands, Eng.	46	10	0
Chinese	31	0	0
Crude	18	10	0

QUICKSILVER.

	£	s.	d.
Quicksilver	23	0	0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon—	
25%	£7 17 6
45/50%	£11 10 0
75%	£19 0 0
Ferro-vanadium—	
35/50%	12/9 lb. Va.
Ferro-molybdenum—	
70/75% c. free	4/2 lb. Mo.
Ferro-titanium—	
23/25% carbonless	9d. lb.
Ferro-phosphorus, 20/25%	£16 0 0
Ferro-tungsten—	
80/85%, c. fr.	3/1½ lb.
Tungsten metal powder—	
98/99%	3/4½ lb.
Ferro-chrome—	
2/4% car.	£30 5 0
4/6% car.	£23 7 6
6/8% car.	£22 12 6
8/10% car.	£22 2 0
Ferro-chrome—	
Max. 2% car.	£33 12 6
Max. 1% car.	£39 0 0
Max. 0.70% car.	£41 12 6
70% carbonless	11d. lb.
Nickel—99% cubes, or pellets	£175 0 0
Ferro-cobalt	9/6 lb.
Aluminium 98/99%	£95 0 0
Metallic chromium—	
96/98%	2/7 lb.
Ferro-manganese (net)—	
76/80% loose	£12 10 0
76/80% packed	£13 10 0
76/80% export	£12 15 0
Metallic manganese—	
94/96%, carbonless	1/4 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten	£0 2 0
Finished bars, 18% tungsten	£0 2 9

Per lb. net, d/d buyers' works.

Extras—

Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to $\frac{3}{16}$ in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb.
Do., under ½ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP.

	£	s.	d.		£	s.	d.
South Wales—							
Heavy steel					3	7	6
Bundled steel and shrngs.	3	3	0	to	3	5	0
Mixed iron and steel	3	2	6	to	3	3	6
Heavy cast iron	2	17	6	to	2	19	0
Good machinery for foundries					3	2	6
Cleveland—							
Heavy steel					3	3	6
Steel turnings					2	16	6
Cast-iron borings					2	13	0
Heavy forge					3	15	0
W.I. piling scrap					3	10	0
Cast-iron scrap	3	2	6	to	3	6	6
Midlands—							
Ord. cast-iron scrap					3	5	0
Heavy wrought					3	17	6
Steel turnings	2	5	0	to	2	7	6
Scotland—							
Heavy steel					3	10	0
Cast-iron borings					2	10	0
Wrought-iron piling					3	18	6
Heavy machinery					3	10	0

London—Merchants' buying prices delivered yard.

	£	s.	d.
Copper (clean)	61	0	0
Brass	43	0	0
Lead (less usual draft)	19	0	0
Tea lead	15	0	0
Zinc	12	10	0
New aluminium cuttings	65	0	0
Braziery copper	57	0	0
Gunmetal	54	0	0
Hollow pewter	132	0	0
Shaped black pewter	98	0	0

PIG-IRON.

(f.o.t. unless otherwise stated.)

N.E. Coast—	
Foundry No. 1	75/-
Foundry No. 3	72/6
Foundry No. 4	71/6
Forge No. 4	71/-
Hematite No. 1	78/6
Hematite M/Nos.	78/-
N.W. Coast—	
Hem. M/Nos. d/d Glas.	87/6
,, d/d Birm.	93/6
Midlands—	
Staffs. common*	—
,, No. 4 forge*	74/6
,, No. 3 fdry.*	78/6
Shrops. basic	—
,, Cold blast, ord.	—
,, ,, roll iron	—
Northants forge*	71/-
,, fdry. No. 3*	75/-
Derbyshire forge*	74/6
,, fdry. No. 3*	78/6
,, basic*	—
Scotland—	
Foundry No. 1	80/6
,, No. 3	78/-
Hem. M/Nos.	81/-
Sheffield (d/d district)—	
Derby forge	69/6
,, fdry. No. 3	73/6
Lincs. forge.	73/-
,, fdry No. 3	77/-
E.C. hematite	89/-
W.C. hematite	91/6
Lincs. (at furnaces)—	
Forge No. 4	—
Foundry No. 3	—
Basic	—
Lancashire (d/d eq. Man.)—	
Derby forge	—
,, fdry. No. 3	77/-
Northants foundry No. 3	—
Dalzell, No. 3 (special)	105/- to 107/6
Summerlee, No. 3	95/-
Glengarnock, No. 3	—
Gartsherrie, No. 3	95/-
Monkland, No. 3	95/-
Shotts, No. 3	95/-

*d/d Black Country dist.

FINISHED IRON AND STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

	£	s.	d.		£	s.	d.
Iron—							
Bars (cr.) nom.					10	15	0
Nut and bolt iron	9	2	6	to	9	7	6
Hoops					11	0	0
Marked bars (Staffs) f.o t.					12	10	0
Gas strip					11	0	0
Bolts and nuts, ¾ in. × 4 in.					15	5	0
Steel—							
Ship plates	8	15	0	to	8	17	6
Boiler plts.	9	15	0	to	10	10	0
Chequer plts.					10	12	6
Angles					8	7	6
Tees					9	7	6
Joists					8	10	0
Rounds and squares, 3 in. to 5½ in.					9	7	6
Rounds under 3 in. to ⅜ in. (Untested)					8	2	6
					and upwards		
Flats—8 in. wide and over					8	12	6
,, under 8 in. and over 5 in.					8	17	6
Rails, heavy					8	10	0
Fishplates					12	10	0
Hoops (Staffs)					9	15	0
Black sheets, 24 g.	9	15	0	to	9	17	6
Galv.cor.shts., 24g.	12	0	0	to	12	5	0
Galv. fencing wire, 8g. plain					12	0	0
Billets, soft	6	2	6	to	6	12	6
Billets, hard	7	10	0	to	8	0	0
Sheet bars	5	17	6	to	6	5	0
Tin bars	5	17	6	to	6	5	0

PHOSPHOR BRONZE.

	Per lb. basis.
Strip	1/4
Sheet to 10 w.g.	1/5
Wire	1/6
Rods	1/5
Tubes	1/9½
Castings	1/4

Delivery 3 cwt. free.
10% phos. cop. £40 above B.S.
15% phos. cop. £50 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	per lb.
Ingots for raising	10d. to 1/4
Rolled—	
To 9 in. wide	1/4 to 1/10
To 12 in. wide	1/4½ to 1/10½
To 15 in. wide	1/4½ to 1/10½
To 18 in. wide	1/5 to 1/11
To 21 in. wide	1/5½ to 1/11½
To 25 in. wide	1/6 to 2/-
Ingots for spoons and forks	10d. to 1/6½
Ingots rolled to spoon size	1/1 to 1/9½
Wire round—	
3/0 to 10 G.	1/7½ to 2/2½

with extras according to gauge.

AMERICAN IRON AND STEEL.

At Pittsburgh unless otherwise stated.

	Dols.
No. 2X foundry, Phila.	20.76
No. 2 foundry, Valley	18.50
No. 2 foundry, Birm.	14.50
Basic	20.26
Bessemer	20.76
Malleable	20.76
Grey forge	19.76
Ferro-mang. 80% d/d	105.00
O.-h. rails, h'y, at mill	43.00
Bessemer billets	35.00
O.-h. billets	35.00
O.-h. sheet bars	35.00
Wire rods	40.00
	Cents
Iron bars, Phila.	2.12
Steel bars	1.90
Tank plates	1.80
Beams, etc.	1.90
Skelp, grooved steel	1.85
Skelp, sheared steel	1.85
Steel hoops	2.20
Sheets, black, No. 24	2.65
Sheets, galv., No. 24	3.30
Sheets, blue an'l'd, No. 13	2.25
Wire nails	2.30
Plain wire	2.40
Barbed wire, galv.	2.95
Tinplates, 100-lb. box	$5.25

COKE (at ovens).

Welsh foundry	32/6 to 35/-
,, furnace	30/0 to 32/6
Durham and Northumberland—	
,, foundry	17/- to 17/6
,, furnace	19/6
Midlands, foundry	—
,, furnace	—

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. cokes	20×14 box		18/9
,,	28×20 ,,		37/6
,,	20×10 ,,		27/-
,,	18½×14 ,,		19/6
C.W.	20×14 ,,		18/-
,,	28×20 ,,		34/6
,,	20×10 ,,		23/1½
,,	18½×14 ,,		16/9
Terneplates	28×20		32/6 per box basis f.o.b.

SWEDISH CHARCOAL IRON & STEEL.

Pig-iron	£6	0	0	to	£7	10	0
Bars, hammered, basis	£17	10	0	to	£18	10	0
Bars and nail-rods, rolled, basis	£15	17	6	to	£16	15	0
Blooms	£10	0	0	to	£12	0	0
Keg steel	£32	0	0	to	£33	0	0
Faggot steel	£20	0	0	to	£24	0	0
Bars and rods dead soft, steel	£11	0	0	to	£14	0	0

All per English ton, f.o.b. Gothenburg.

TUBES AND FITTINGS.
Over ¼ in. up to 6 in.

	Tubes.	*Fittings.*
Gas	65%	47½%
Water	61½%	42½%
Steam	57½%	37½%

W.I. 10% extra.

DAILY FLUCTUATIONS.

Standard Copper (cash).

			£	s.	d.		
Jan.	23	..	71	10	0	dec.	7/6
,,	24	..	71	10	0	No	change
,,	27	..	71	10	0	,,	,,
,,	28	..	71	10	0	,,	,,
,,	29	..	71	16	3	inc.	6/3

Electrolytic Copper.

			£	s.	d.			
Jan.	23	..	83	5	0	No	change	
,,	24	..	83	5	0	,,	,,	
,,	27	..	83	5	0	,,	,,	
,,	28	..	83	5	0	,,	,,	
,,	29	..	83	10	0	inc.	5/-	

Standard Tin (cash).

			£	s.	d.			
Jan.	23	..	172	0	0	inc.	22/6	
,,	24	..	172	10	0	,,	10/-	
,,	27	..	174	10	0	,,	40/-	
,,	28	..	176	7	6	,,	37/6	
,,	29	..	180	10	0	,,	82/6	

Tin (English ingots).

			£	s.	d.			
Jan.	23	..	173	0	0	inc.	25/-	
,,	24	..	173	15	0	,,	15/-	
,,	27	..	175	10	0	,,	35/-	
,,	28	..	177	10	0	,,	40/-	
,,	29	..	182	0	0	,,	90/-	

Zinc Sheets (English).

			£	s.	d.			
Jan.	23	..	30	0	0	No	change	
,,	24	..	30	0	0	,,	,,	
,,	27	..	30	0	0	,,	,,	
,,	28	..	30	0	0	,,	,,	
,,	29	..	30	0	0	,,	,,	

Spelter (ordinary).

			£	s.	d.		
Jan.	23	..	19	15	0	inc.	1/3
,,	24	..	19	16	3	,,	1/3
,,	27	..	19	17	6	,,	1/3
,,	28	..	19	16	3	dec.	1/3
,,	29	..	20	1	3	inc.	5/-

Lead (English).

			£	s.	d.		
Jan.	23	..	23	0	0	No	change
,,	24	..	23	0	0	,,	,,
,,	27	..	23	0	0	,,	,,
,,	28	..	23	0	0	,,	,,
,,	29	..	23	0	0	,,	,,

AVERAGE MONTHLY PRICES OF FURNACE COKE, D/D MIDDLESBROUGH.

Year.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1895	0 12 3	0 12 3	0 12 3	0 12 3	0 12 3	0 12 3	0 12 3	0 12 3	0 12 6	0 13 3	0 13 3	0 13 3	0 12 5½
1896	0 13 0	0 13 0	0 13 6	0 13 6	0 13 6	0 13 9	0 13 6	0 13 3	0 13 3	0 13 3	0 13 6	0 13 6	0 13 4½
1897	0 13 6	0 13 6	0 13 6	0 13 3	0 13 3	0 13 6	0 13 6	0 13 6	0 13 3	0 13 3	0 13 0	0 13 6	0 13 4½
1898	0 13 6	0 13 6	0 15 0	0 13 6	0 13 9	0 14 0	0 14 3	0 14 3	0 14 6	0 14 9	0 15 0	0 15 6	0 14 3½
1899	0 15 6	0 15 6	0 16 0	0 16 3	1 0 0	1 1 0	1 1 6	1 1 6	1 1 6	1 1 0	1 2 0	1 5 0	0 19 8½
1900	1 5 0	1 5 6	1 6 6	1 8 0	1 8 6	1 9 0	1 9 0	1 8 0	1 8 0	1 7 0	1 3 0	0 19 0	1 6 4½
1901	0 17 6	0 14 0	0 13 0	0 14 0	0 14 6	0 15 0	0 15 3	0 15 3	0 15 9	0 16 6	0 16 9	0 16 9	0 16 4½
1902	0 16 9	0 15 0	0 15 0	0 15 0	0 15 0	0 15 3	0 15 3	0 15 3	0 15 6	0 16 0	0 16 6	0 16 0	0 15 5
1903	0 15 9	0 16 0	0 16 3	0 16 9	0 16 6	0 16 3	0 16 0	0 15 9	0 15 6	0 15 0	0 14 6	0 14 0	0 15 8½
1904	0 13 9	0 13 9	0 13 3	0 14 3	0 14 6	0 14 3	0 14 3	0 14 3	0 14 3	0 14 0	0 14 0	0 14 6	0 14 1½
1905	0 14 9	0 15 3	0 15 3	0 15 3	0 15 6	0 15 6	0 15 6	0 15 6	0 15 6	0 15 6	0 15 9	0 17 0	0 15 5½
1906	0 17 6	0 17 6	0 17 0	0 17 0	0 17 0	0 16 6	0 17 0	0 17 0	0 18 3	0 18 6	0 19 0	1 0 0	0 17 8½
1907	1 4 6	1 5 0	1 5 0	1 0 6	1 2 0	1 1 0	1 1 0	1 1 0	1 2 0	1 1 6	1 0 0	0 17 0	1 1 8½
1908	0 16 0	0 16 0	0 15 6	0 16 0	0 16 3	0 16 0	0 15 6	0 15 6	0 15 6	0 15 3	0 16 0	0 16 0	0 15 9½
1909	0 16 0	0 15 3	0 15 0	0 14 9	0 15 6	0 15 9	0 15 6	0 15 6	0 16 6	0 17 0	0 17 6	0 17 0	0 15 11½
1910	0 18 4½	0 18 6½	0 18 0	0 18 0	0 17 10½	0 17 0	0 16 1½	0 15 9½	0 15 11	0 16 0	0 15 9½	0 15 8	0 16 11
1911	0 16 6	0 15 10½	0 15 6	0 15 3	0 14 9	0 14 6	0 14 6	0 14 6	0 14 6	0 14 11½	0 15 0½	0 16 3½	0 15 1½
1912	0 17 3	0 17 3	0 18 6	0 18 10	0 19 0	0 19 4½	0 19 10½	1 0 9½	1 2 9	1 4 1½	1 5 8½	1 8 6	1 1 0
1913	1 5 9	1 4 11	1 5 0	1 5 0	1 4 9½	1 0 4½	0 19 5½	0 18 3	0 18 0	0 18 2½	0 18 6	0 18 6	1 1 4½
1914	0 18 2	0 17 1	0 17 0	0 17 0	0 17 4	0 17 6	0 17 6	0 18 5	0 18 4	0 17 9	0 17 6	0 18 5	0 17 8
1915	0 17 10½	0 17 9	1 0 4½	1 7 7½	1 9 4½	1 10 7½	1 9 7	1 7 3	1 5 4	1 4 9	1 9 6	1 13 0	1 6 1
1916	1 10 9	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6½
1917	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 14 3	1 15 6	1 11 2½
1918	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6
1919	1 15 6	1 15 6	1 15 6	1 15 6	2 1 6	2 1 6	2 3 9	2 10 6	2 10 6	2 10 6	2 10 6	2 10 6	2 3 5
1920	2 12 3	2 14 0	2 19 0	2 19 0	3 3 8	3 6 0	3 6 0	3 6 0	3 6 0	3 6 0	3 6 0	3 6 0	3 2 6
1921	3 1 0½	2 19 0	2 16 0	2 7 0	2 6 6	2 6 6	2 0 6	2 0 0	1 13 11	1 12 9	1 10 4½	1 8 3	2 3 6½
1922	1 7 0½	1 8 1½	1 9 7½	1 8 4½	1 7 11½	1 7 3	1 6 9½	1 6 10½	1 7 0½	1 10 2½	1 10 0	1 9 11½	1 8 3½
1923	1 11 3	1 14 6	2 0 1½	2 2 8½	2 4 4½	2 2 10½	2 1 0½	2 1 6	2 0 9½	1 18 9	1 18 8½	1 18 3	1 19 7½
1924	1 16 6½	1 14 9	1 11 11½	1 10 0½	1 8 1½	1 7 8½	1 7 3	1 6 3	1 6 0	1 5 0	1 5 0	1 5 0	1 9 5½
1925	1 4 10½	1 4 1½	1 13 3	1 2 4½	1 2 2½	1 1 5½	1 1 3½	1 4 9	0 18 10½	0 18 4½	0 19 6½	1 1 4½	1 2 8½ (5 months)
1926	1 2 1½	1 0 9	0 19 2½	0 18 6½	Strike	Strike	Strike	Strike	Strike	Strike	Strike	1 5 0	1 1 1½
1927	1 5 6	1 4 9½	1 6 1½	1 3 9	1 2 6	1 0 8½	0 19 4½	0 19 0	0 18 7½	0 18 0	0 17 10½	0 17 6	1 1 1½
1928	0 17 6	0 17 10½	0 18 0½	0 17 11½	0 17 8½	0 17 6½	0 17 7½	0 17 6½	0 17 6	0 17 7½	0 17 7½	0 17 6	0 17 8
1929	0 17 7½	0 18 0	0 19 0	0 19 6½	0 18 10½	0 19 10½	1 1 3½	1 1 8½	1 3 0	1 3 6	1 3 8	1 3 1½	1 0 9½

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